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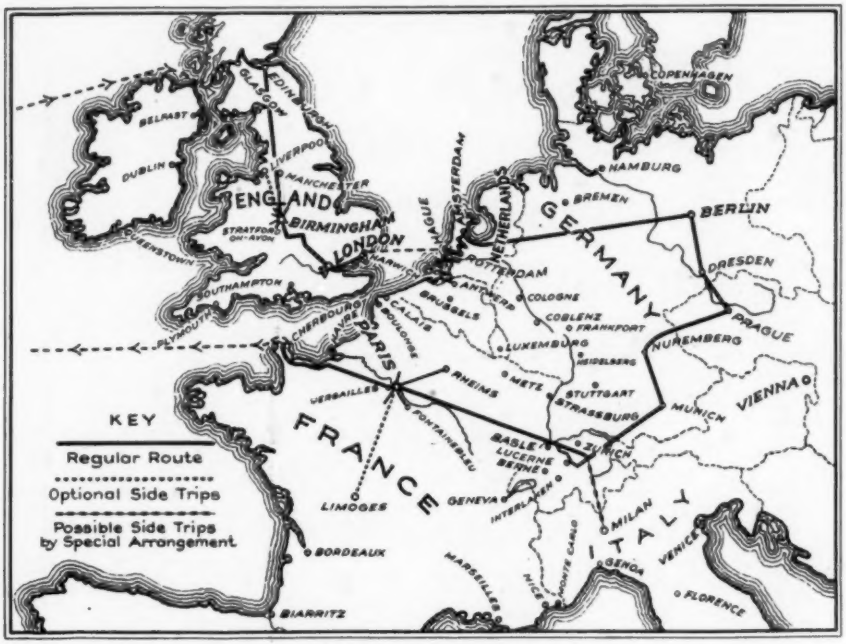

Proposed Itinerary for American Ceramic Society European Tour

The American Ceramic Society

Tour Department

25 Broadway, New York City

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OCTOBER, 1927

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A PRELIMINARY STUDY OF CERAMIC COLORS AND THEIR USE IN VITREOUS ENAMELS[1]

By W. N. Harrison and T. D. Hartshorn

ABSTRACT

This report deals with the results obtained from a study of ceramic colors as used in vitreous enamels. Numerous coloring stains were produced and used in various enamel compositions. The batch formulas of the stains are given, and methods of preparation described.

To obtain uniformity of texture of the colored enamels, and to insure accuracy of duplication in preparing successive batches of a given stain, it was found desirable to (*a*) accurately duplicate time and temperature of calcination, and in some cases furnace atmosphere; (*b*) wash the stains free from soluble matter after calcination; (*c*) grind and pass them through a fine screen before use; and (*d*) keep the enamel composition constant.

Several of the stains were produced on a relatively large scale and tested commercially under plant conditions. These gave excellent results.

I. Introduction

Vitreous enamels for sheet iron and cast iron are rapidly assuming increased importance in the economic application of these metals for their protection against corrosion and other deterioration and for decoration. The demand for colored enamels is growing rapidly, as evidenced by the increasing number of advertising signs, restaurant fixtures, stove parts, and other articles enameled in color. Coloring agents in very small amounts are sometimes used to give a slight color or tone to a "white" enamel or to mask an undesirable tone. Thus to counteract a blue tone, additions of yellow stain are made, and to produce blue-white enamels, small amounts of cobalt salts are added.

Although considerable care must be taken to produce a good white enamel, even more skill is required in the production of satisfactory colored ware, especially when a particular shade must be accurately reproduced. The ceramic literature is limited in direct references to stains which are useful to manufacturers of colored enameled ware, although some references to colors for glazes and glasses suggest compositions which might be used. It was the purpose of this investigation to develop practical means for producing and reproducing enamels in a limited number of colors from which a large number of other colors and shades are obtainable by blending. It may be assumed that the methods of control found necessary for the colors investigated are largely applicable to all.

II. Methods of Producing and Applying Colored Enamels

In producing a vitreous enamel the first step is to assemble the raw ingredients in the proper proportions and mix them thoroughly. The

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce. Received July 13, 1927.

mix is then melted to form a glass, which is shattered by sudden cooling to facilitate the subsequent grinding. In the wet process, which is the one generally used in producing colored enamels, the shattered glass, or frit, is ground in a ball mill with water and certain additions of materials intended either to influence the consistency of the suspension of powdered frit in water or to contribute some desirable quality to the finished ware. This enamel suspension, in practice called a slip, is used to coat the surface of the metal shapes and after evaporation of the water the adhering powder is fused to give a smooth, continuous surface.

There are two stages in this process at which coloring agents can be introduced. In some cases they are included in the raw batch and produce a colored frit. Blue and black enamels especially are often made in this way, and typical batch compositions are shown in Table I. Since it is usually inconvenient to store large quantities of colored frits, and furthermore because many coloring agents can not withstand the relatively long and severe heat treatment incident to fusion of the raw batch to form a glass, it is customary to keep on hand a supply of standard frit and include any desired stain with the mill additions. This treatment results in a very intimate mixing of the stain with the particles of frit, and gives a uniform color in the finished piece when a satisfactory stain is used. Colored enamels prepared in this way should be ground finer than otherwise necessary, in order to insure even texture and distribution of the stain. This fine grinding permits decreasing the amount of clay added to the mill batch for floating the frit particles, a circumstance which is fortunate because clay in relatively large amounts impairs the appearance of colored enamels. Some manufacturers have entirely eliminated the use of clay in colored enamels, but this practice invites difficulty in obtaining slips of the desired consistency.

In order to produce colors of a particular tone or shade, standard colors may be blended. Lighter shades may be obtained by blending a white enamel with the colored enamel; shades of brown may be produced by mixing red, yellow, and blue slips, and of green by blending blue and yellow slips. Another method of producing various shades is the blending of standard stains before introducing them into the mill batch.

III. Scope and Plan of Work

This investigation is concerned principally with the compositions and processes involved in the production of colored enamels by the introduction of stains into the mill batch. Since opportunities for irregularities occur in the preparation as well as the application of the coloring agents, the work was directed first to the preparation of a group

of satisfactory stains and a study of the factors which govern the accuracy of their reproduction. The investigation was then directed to a study of the effect of some variations in composition of the enamel frit upon the shades obtained with given stains.

Each of the stains developed was tested by use with a clear frit designed for color work. The colored slips were sprayed on small test pieces which had already been given a ground coat and two white cover coats and, after drying, were fired in a small electric furnace. Besides the clear frit others, varying systematically in composition, were used to determine the effect of the variations upon the color produced with a given stain.

No work was done on the use of various opacifiers in the production of white opaque enamels, since this phase was covered in a previous investigation at this Bureau.[1]

IV. Preparation of Coloring Stains

The raw materials were weighed in approximately 100-gram batches, thoroughly mixed, sieved, and calcined in trial heats until a satisfactory time and temperature for calcining each stain was determined. The stains requiring a relatively high temperature for calcination were heated in fired clay crucibles in the closed muffle of a small gas-fired pottery kiln. The heat treatment was regulated by the aid of pyrometric cones placed in the muffle with the crucibles. The cone numbers given in the tables refer in each case to the highest numbered cone which was deformed to a "cone down" position. The crucibles containing the batches were placed in the muffle at room temperature and, after the desired temperature had been reached and the flame cut off, allowed to remain there overnight so that they would be cool enough for convenient handling. Two types of firing schedule were used with this gas-fired muffle furnace. The first was to set the burners so that the temperature would be approximately 1000°C (1800°F) in seventeen hours, after which the temperature was raised at the rate of 20°C (36°F) per hour until the desired cone had deformed. This procedure will be referred to as calcination treatment *A*. The other, which will be called calcination treatment *B*, was to raise the temperature at such a rate that the firing was complete in seven hours.

The stains requiring a brief calcination at a relatively low temperature were calcined in a small electric furnace. In this case the crucibles were placed in the hot muffle, which was kept at approximately

[1] R. R. Danielson and M. K. Frehafer, "Effect of Some Substitutes for Tin Oxide on the Opacity of White Enamels for Sheet Steel," *Jour. Amer. Ceram. Soc.*, **6** [5], 634 (1923).

the same temperature throughout each treatment. The temperatures were measured with a platinum-rhodium thermocouple.

The calcined stains were washed by decantation several times with hot water to remove soluble material, a treatment which was very effective in eliminating a scummy spotted appearance. They were also ground in a mortar to pass a No. 200 sieve in order to secure a uniform texture in the finished pieces.

1. Blue A uniformly blue enamel, satisfactory for the darker shades, may be obtained by mixing thoroughly a small amount of black cobalt oxide (Co_3O_4) with the enamel raw materials before melting, as indicated in Table I. In this case the color-producing ingredient becomes an integral part of the enamel while it is in a molten state. The raw materials should be thoroughly mixed before melting in order to distribute the cobalt uniformly. Attention to this detail eliminates considerable stirring in the process of melting, although a certain amount is always necessary. The fusion should be complete, as indicated by drawing through the fingers a thread of the glass, which should be perfectly smooth throughout its length. The range of shades which may be produced in enamels by this method is rather wide, and the resultant tone can be controlled by the quantity of oxide used. About 7% of the oxide may be considered as a maximum since this amount will produce probably as dark a shade as would be required.

TABLE I

ENAMELS IN WHICH THE COLORING AGENT IS INCLUDED WITH THE RAW MATERIALS BEFORE MELTING

Dark Blue		Black	
Ingredient	Parts by weight	Ingredient	Parts by weight
Borax	26.0	Borax	28.0
Potash feldspar	15.0	Potash feldspar	30.0
Quartz	26.0	Quartz	20.0
Soda ash	7.0	Soda ash	3.0
Soda nitrate	3.0	Soda nitrate	3.0
Fluorspar	4.0	Fluorspar	5.0
Zinc oxide	6.0	Cobalt oxide	2.0
Red lead	4.5	Manganese oxide	4.0
Cobalt oxide	7.0	Black copper oxide	2.0
		Black iron oxide	1.0
		Chromic oxide	2.0

Although these blue frits have wide application, it is desirable to have also blue stains which can be added at the mill. This is true not only because the same frit can then be used for other colors, but also because many of the lighter and more delicate shades of blue can be obtained more readily by the method of mill addition.

The compositions of three stains of this type are given in Table II. These were all put through the regular course of preparation which has been described, including thorough mixing of raw materials, calcining, washing, and regrinding to pass a 200-mesh sieve. Number 1 was given

TABLE II
BLUE STAINS

No.	Shade	Calcined to cone	Batch Weights: Aluminum oxide	Cobalto-cobaltic oxide	Cobaltous chromate*	Zinc oxide
1	Medium dark blue	12	55.4	44.6		
2	Medium light blue	8	51.6		28.2	20.2
3	Light blue	8	54.8		7.4	37.8

* Cobaltous chromate may be prepared by precipitation from a solution of 154.8 parts of anhydrous cobaltous sulphate ($CoSO_4$) with a solution of 97.1 parts of potassium chromate ($KCrO_4$). The precipitate should be thoroughly washed with water and ignited at a low temperature (300°C to 400°C).

calcination treatment *B* and Nos. 2 and 3 were given treatment *A*. Each of these stains gave excellent results when added at the mill in a quantity equal to 3% (by weight) of the frit. The function of the aluminum and zinc oxides may be regarded from a mechanical standpoint as that of a diluent. The chromium in the two lighter stains tends to shift the resultant color toward the lighter (yellow) part of the spectrum, and thus the colors obtained with these two stains are not untinged with green, but nevertheless are so essentially blue that they are classified as such.

2. Green The simplest and most serviceable dark grass-green enamel was prepared by adding 3% of chromic oxide to the mill batch. For a wide range of shades, however, the compositions given in Table III gave good results.

TABLE III
GREEN STAINS

No.	Shade	Calcined to cone	Batch Weights: Chromic oxide	Nickelic oxide	Silica	Potassium dichromate	White lead	Calcium carbonate	Potassium nitrate	Calcium chloride	Fluorspar
1	Dark green	12	66.2	33.8							
2	Medium "	5	50.0		35.0	7.0	3.5	3.5	1.0		
3	Light "	8			20.0	36.0		20.0		12.0	12.0

To produce stain No. 1 (Table III) the two ingredients were ground with a mortar and pestle to pass a No. 80 sieve, mixed by rolling, calcined by treatment *B*, and reground. A similar procedure was used for No. 2, although the potassium dichromate may be added in solution as in No. 3. For stain No. 3 the quartz, calcium carbonate, and fluorspar were ground wet, the water decanted, and the calcium chloride and potassium dichromate added in concentrated solution. The mass was dried, well mixed, and calcined by treatment *A*. A stain giving a more brilliant color was obtained when the furnace atmosphere was kept in a reducing condition by adjustment of the gas flame.

It was found that when a formula calls for the use of potassium dichromate, chromic oxide could usually be substituted in molecularly

equivalent amounts. At times the potassium dichromate was not entirely decomposed during calcination, and a very thorough washing was found necessary, while a small amount of washing was sufficient when chromic oxide was used. This was true also of other stains in which chromium was used.

3. Blue-Green Various shades of blue-green colors may be produced by mixing blue and green stains in the proper proportions with the mill addition, although this is not usually done. Satisfactory blue-green stains may be prepared by calcining mixtures of cobalt oxide, chromic oxide (or potassium dichromate), and calcined alumina. The latter, which serves here also as a diluent, may be used in amounts up to two-thirds of the whole without unduly affecting the gloss and texture of the finished product. Four compositions of this type are shown in Table IV.

TABLE IV
BLUE-GREEN STAINS

No.	Shade	Calcined to cone	Cobalto-cobaltic oxide	Chromic oxide	Potassium dichromate	Aluminum oxide
1	Dark blue-green	6	55.5		11.5	33.0
2	Medium dark blue-green	6	35.5		31.5	33.0
3	Blue-green	6	24.0	12.0		64.0
4	Light blue-green	6	6.2		37.5	56.3

No variation from the regular procedure was necessary in the preparation of these stains; the ingredients were all put through a No. 80 sieve, mixed thoroughly, calcined by treatment *A*, washed by decantation, and ground in a mortar to pass a No. 200 sieve. A 3% mill addition of these stains produced enamels of excellent appearance.

4. Yellow The compound which is most commonly used in the preparation of yellow enamels is cadmium sulphide. A variety of shades, ranging from lemon-yellow to a brilliant yellow-orange, may be obtained by varying the per cent of this stain. It is added at the mill, and 3% gives as deep a tone as would be required of a yellow enamel. Cadmium sulphide has a tendency to "burn out," and for this reason the firing treatment of the enamel should be closely duplicated in order to reproduce a given tone accurately.

A good lemon-yellow color was obtained with 3% lead chromate added at the mill. This compound was obtained by precipitation, using a mixture of solutions of lead acetate and potassium dichromate. The lead chromate was removed and washed by decantation, dried at 110°C (230°F), and ground in a mortar to pass a No. 200 sieve before use. This stain also has a tendency to burn out, but is not extremely sensitive to variations in firing treatment.

Antimony and lead together in an enamel tend to give a yellow color,[1] and a very light yellow or ivory was obtained with the use of a stain

[1] "Materials and Methods Used in the Manufacture of Enameled Cast Iron Wares," Bur. Stand., *Tech. Paper*, No. 142 p. 89.

containing these two constituents. The stain was made up of the following constituents in the indicated proportions by weight: 8 aluminum oxide, 16 tin oxide, 32 antimony trioxide, and 44 red lead. The usual grinding and sieving was carried out before and after the calcination. The stain was calcined by treatment *B* to cone 12 (approximately 1370°C or 2498°F) and used as a 3% mill addition.

5. Brown Various shades of brown were produced successfully with the compositions shown in Table V. These stains were prepared by the general procedure which has been described. Numbers 2 and 3 were given calcination treatment *A* and Nos. 1, 4, and 5 were given treatment *B*. Moderate variations in the per cent of the diluents (aluminum and zinc oxides) shown in Table V appeared to have little if any effect upon the resulting colors. The medium dark brown and red-brown compositions are very similar with the exception of the substitution of zinc oxide for aluminum oxide. The corresponding color change is from a grayish-brown to a brighter red-brown.

TABLE V
BROWN STAINS

No.	Shade	Calcined to cone	Batch Weights: Aluminum oxide	Potassium dichromate	Chromic oxide	Ferric oxide	Zinc oxide	Manganese dioxide
1	Dark brown	1			49.0			51.0
2	Medium dark brown	8	47.5	34.0		18.5		
3	Red-brown	8		35.0		19.0	46.0	
4	Tan	1	11.4		16.9	17.8	54.0	
5	Tan	1	9.6	30.2		15.1	45.1	

No difficulty was experienced in the duplication of shades in preparing different batches of these stains which appeared to be generally satisfactory.

6. Black and Gray Although most color tones can be obtained by the use of 3% or less stain, it is necessary to use from 5% to 10% of black stain for satisfactory results. The compositions of five black stains are given in Table VI. These were all given calcination treatment *B*. The best was No. 2, though Nos. 3 and 4 produced nearly as good color. Since Nos. 1 and 2 are not widely different in composition, it is possible that the difference in their calcination temperatures is responsible for the less satisfactory results obtained with No. 1. In comparison with the other compositions, No. 5 was slightly lacking in luster and covering power. Black copper oxide (CuO) is often used in the preparation of black frits,[1] but when used in a calcined stain to be added at the mill it tends to promote blistering of the enamel.

Some very satisfactory gray enamels were made by using 1% or less of a black stain in the mill batch. A mixture of 35 parts iron oxide

[1] See Section II of this paper, "Methods of Producing and Applying Colored Enamels," p. 747.

(Fe_2O_3) and 65 parts aluminum oxide (Al_2O_3), calcined to cone 8 by treatment *B* also produced a serviceable gray stain.

7. Red Because of the difficulty which is usually encountered in the duplication of shades in red enamels, more study and experimental work was accorded to the investigation of red stains than to those previously discussed. Various materials have been used to

TABLE VI
BLACK STAINS

No.	Calcined to cone	Batch Weights: Cobalto-cobaltic oxide	Chromic oxide	Manganese dioxide	Ferric oxide	Nickelic oxide
1	010	18.0	18.0	45.0	18.0	
2	5	15.8	15.8	52.6	15.8	
3	6	18.7	18.7		31.3	31.3
4	6	18.7	18.7	31.3		31.3
5	6	49.0	12.0	39.0		

produce red shades, including gold chloride ($AuCl_3$), but because of its expensiveness its use is limited to the field of art. Certain red stains produced with iron may be used in enamels maturing at very low temperatures, but the temperatures required for the ordinary commercial enamels causes a volatilization of the color.

The only satisfactory red stains produced in this investigation contained selenium and cadmium and sulphur. Cadmium sulphide and selenium have been used for a considerable time in the glass industry to produce ruby glass. If sulphur and selenium are melted together, a brilliant red gumlike mass is produced.

The compositions given in Table VII were the most successful of those tried. The color produced by each of these red stains was quite sensitive to variations in the severity of the calcination treatment of the stain and the firing treatment of the enamel. The calcination of

TABLE VII
RED STAINS

No.	Shade	Calcining: Time (minutes)	Temperature °C	°F	Batch Weights: Powdered black selenium	Cadmium sulphide	Cadmium oxide	Sulphur flowers
1	Yellow-red	8	550	1022	11.9	64.6	23.5	
2	Light red	5	600	1112	17.4	65.2	17.4	
3	" "	5	500	932	19.7		49.1	31.2
4	Medium red	5	550	1022	20.0	72.0	8.0	
5	Dark red	5	450	842	19.2	57.7	23.1	

these stains, as indicated in Table VII, was carried out at much lower temperatures and for much shorter periods than were required for the other stains. The calcining treatment was different for these stains also in that they were placed in a hot muffle, which was kept as nearly uniform in temperature as possible during calcination. Selenium was used in the powdered metallic form, since it was found by experiment that the

red amorphous material, which is more expensive, produced no better results.

Because of variations in time and temperature of calcination no definite relation can be drawn from Table VII concerning the effect of composition alone upon the shade. An increase in the selenium and cadmium content, however, with a corresponding decrease in sulphur

TABLE VIII

EFFECT OF CALCINATION ON COMPOSITION OF A RED STAIN

Before Calcination		Chemical Composition after Calcination	
Ingredients	Parts by weight	Ingredients	Parts by weight
Selenium	11.3	Selenium	13.3
Cadmium oxide	70.9	Cadmium	70.8
Sulphur	17.8	Sulphur	13.0
Total	100.0	Iron oxide	0.2
		Total	97.3

did tend to produce a darker red, and a reversal of this practice resulted in a lighter shade. A longer period of heat treatment or a higher temperature also darkened the color, an effect which was probably due, at least in part, to the loss of sulphur through volatilization. This view is strengthened by the chemical analysis of a stain before and after calcination which, as shown in Table VIII, indicated a loss of more than one-fourth in the sulphur content.

The fact that 2.7% of the calcined stain was unaccounted for in the chemical analysis may be due to the difficulty of a complete and accurate separation of selenium and sulphur in the presence of cadmium, or else some of the cadmium may be present as the oxide. If it is assumed that all the selenium is combined as cadmium selenide, all the sulphur as cadmium sulphide, and the remaining cadmium as the oxide, the theoretical composition given in Table IX results.

TABLE IX

CALCULATED CHEMICAL COMPOSITION OF A RED STAIN

Ingredients	Parts by weight
Cadmium selenide	32.2
Cadmium sulphide	58.6
Cadmium oxide	7.2
Iron oxide	0.2
Total	98.2

The stains here reported gave very good results when used alone as 3% mill additions. A more uniform and brilliant color of lighter shade was produced when a small amount of cadmium sulphide was added to the mill batch with the red stain. A stain producing a darker red than is desired may be toned to the proper shade in this manner.

In a paper on the utilization of selenium, Sugie[1] discusses various selenium-cadmium sulphide mixtures. A variation in proportions is reported, ranging from 18 parts selenium and 82 parts cadmium

[1] S. Sugie, *Jour. Jap. Ceram. Assn.*, **341**, 152–55; **342**, 193–95; **343**, 226–30 (1921); *Ceram. Abs.*, **1**, 287 (1922).

sulphide to 10 parts selenium and 90 parts cadmium sulphide. The corresponding change is from a blackish red to a yellowish red. Compositions of so-called fire-red stains from Germany were also given. They contained cadmium, selenium, and sulphur, with from 36% to 54% aluminum oxide as a filler. In the present investigation better results were obtained without the use of any such body-giving material.

V. Some Effects of Enamel Composition on Color

It is a recognized fact that the shade of color obtained with a given stain is to some extent dependent upon the composition of the enamel and there is a small amount of information on this subject in the literature. Fukudo[1] states that the addition of tin oxide, antimony oxide, or bone ash tends to produce a clear color. He also reports that zinc oxide, magnesia, lime, and silica make the color dark or "gloomy."

TABLE X

ENAMELS OF GROUP 1 USED WITH VARIOUS STAINS

Ingredients	Batch Compositions Parts by weight No. 1	No. 2	No. 3	Ingredients	Calculated Melted Compositions Parts by weight No. 1	No. 2	No. 3
Borax	27.3	25.0	21.0	Feldspar	29.0	39.3	38.0
Feldspar	23.4	32.0	32.9	Silica	38.6	22.1	12.0
Quartz	31.2	18.0	10.4	Boric oxide	13.6	8.1	8.9
Soda ash	9.8	4.0	4.7	Sodium oxide	14.0	8.2	7.2
Soda nitrate	3.0	3.0		Potassium oxide			1.3
Potash nitrate			2.3	Fluorspar		4.9	5.4
Cryolite	4.0	12.0	3.8	Cryolite	4.9	14.7	4.3
Fluorspar		4.0	4.7	Antimony oxide		2.5	
Boric acid	1.5			Zinc oxide			7.1
Zinc oxide			6.1	Lead oxide			15.8
Red lead			14.0				
Antimony oxide		2.0					

Mill Batch

Ingredients	Parts by weight
Frit	100.0
Clay	6.0
Magnesium Carbonate	0.5
Stain	3.0
Water	45.0

Two different groups of enamels were prepared for use in obtaining data on this subject. The batch weights of the first group are shown in Table X, and the second in Table XI. The batches were melted in a gas-fired hearth melting furnace and 2-pound lots were ground in small porcelain ball mills to pass a No. 100 sieve. The usual practice was to add, at the mill, a weight of coloring material equal to 3% of the frit. Exceptions to this rule were made with the black stain, of which 1% was added for gray and 5% for black. The colored enamels were sprayed on 2- by 3-inch test pieces made of No. 18 gage enameling iron which had been previously given a ground coat and two white cover coats. The white cover enamel used was No. 2 of Table X with an

[1] T. Fukudo, *Jour. Jap. Ceram. Assn.*, **348**, 432–38 (1921); *Ceram. Abs.*, **1**, 294 (1922).

TABLE XI
ENAMELS OF GROUP 2 USED WITH VARIOUS STAINS

Batch Compositions

Ingredients	A–1	A–2	A–3	A–4	B–1	B–2	B–3	B–4	C–1	C–2	C–3	C–4
Feldspar	60.0	60.0	60.0	60.0	35.0	35.0	35.0	35.0				
Quartz					25.0	25.0	25.0	25.0	60.0	60.0	60.0	60.0
Borax	40.9	40.9	40.9	40.9	40.9	40.9	40.9	40.9	40.9	40.9	40.9	40.9
Sodium nitrate	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Soda ash	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Cryolite	10.0				10.0				10.0			
Fluorspar		10.0				10.0				10.0		
Sodium antimonate			10.0				10.0				10.0	
Zinc oxide				10.0				10.0				10.0

Calculated Melted Compositions

Feldspar	60.0	60.0	60.0	60.0	35.0	35.0	35.0	35.0				
Silica					25.0	25.0	25.0	25.0	60.0	60.0	60.0	60.0
Boric oxide	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Sodium oxide	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Cryolite	10.0				10.0				10.0			
Fluorspar		10.0				10.0				10.0		
Sodium antimonate			10.0				10.0				10.0	
Zinc oxide				10.0				10.0				10.0

Mill Batch

Ingredients	Parts by weight
Frit	100.0
Clay	6.0
Stain	3.0
Magnesium carbonate	0.5
Water	50.0

addition of 7% tin oxide in the mill batch. After drying, each piece was brushed to show a white border, a stencil being placed over the middle of the plate to protect the part of the adhering colored coating which it was not desired to remove. In many cases enamels as they come from the mill will not show sharp and clear-cut borders after this stenciling treatment unless they are previously given special treatment. Several binders for improving them in this respect may be used, among the most suitable being gum tragacanth.

All the color specimens were fired in a small electric resistance furnace except selenium-red, which gave better results in the larger gas-fired muffle furnace. The selenium-red stains, being more sensitive to variations in heat treatment than the others, showed more difference in the results obtained with the two furnaces. This effect may be attributed to the fact that the large furnace dropped in temperature very little when the pieces were introduced, whereas the temperature in the small furnace dropped considerably.

Various shades were obtained when the stains were used with different enamels. Other factors being constant, it was found that the opaque frit (No. 2, Table X) consistently gave a light shade, the leadless frit (No. 1) an intermediate shade, and the lead frit (No. 3) produced a dark shade. The greatest difference was evident in the reds.

To obtain additional information it was decided to use twelve enamels differing by systematic variations in the percentages of feldspar, quartz, cryolite, fluorspar, sodium antimonate, and zinc oxide. (See Table XI.) These differences were so arranged that the enamels could be compared with regard to individual constituents. Upon making such a comparison it was found that increase of silica at the expense of feldspar produced little change in color except in the presence of zinc oxide or sodium antimonate, which gave darker colors with high silica and low feldspar content. Aside from a slight lightening of tone, probably due to their opacifying effect, cryolite and fluorspar produced no noticeable change. Zinc oxide darkened the shade slightly in direct proportion to the increase of silica at the expense of feldspar. Sodium antimonate showed the greatest influence, producing an enamel of considerably darker color in spite of its tendency to opacify. The red colors were the most sensitive to changes in composition, as well as to other factors.

VI. Factory Use of Stains Developed in This Investigation

Approximately twenty pounds each of four of the stains described in the preceding pages were prepared and used in two factories for trial purposes. These were light blue (No. 2, Table II), blue-green (No. 2, Table IV), black (No. 2, Table VI), and red stain (No. 3, Table VII). The raw materials were ground, sieved, and mixed as with the small

batches. Then (except in the case of the red stain) each batch was placed in several crucibles holding about four pounds each and all calcined at one time in a muffle furnace, after which it was ground, sieved, washed, and dried as with the smaller batches.

The red stain was mixed in a single batch, separated into batches of about two pounds each, and calcined separately. This was done in the small resistance furnace which had been used for preparing the red stains used in the laboratory work. The calcination treatments were carried out as indicated in Table VII and all the batches mixed together to insure uniformity before grinding and sieving.

Three per cent of the blue, blue-green, and red stains were used, 1% of the black stain to produce a gray color, and 5% for a black color. The results obtained in the factory tests were uniformly excellent with the possible exception of the black stain in plant A which produced pieces that were not quite as black as might be desired when using 5% of the stain. When added in amounts of 1%, however, very satisfactory gray was obtained, and plant B was successful in producing both gray and black enamels.

The compositions of the enamels used in the plants are not known, but it seems probable that the difference in results was due to difference in composition of the enamels, and that the particular enamel used in plant A required a heavier mill addition of the black stain. The color produced with the red stain in plant B was considerably darker than that produced in plant A. This difference was not surprising since the laboratory experiments had already shown that the red stain was especially sensitive to variations in enamel composition and firing treatment.

The blue, blue-green, and gray colors obtained in the two plants were only slightly different in shade. Each plant checked its own results with the black and red stains very well and the indication is that each of the stains tried in the plants is satisfactory for commercial use.

VII. Summary and Conclusions

It was not within the scope of this work to make an exhaustive study of all compositions which seemed to offer possibilities of development as satisfactory stains. It is believed, however, that the results obtained are of value in that they form the basis for a contribution to a field of literature which has previously been very incomplete. The more important findings are briefly reviewed in the following paragraphs.

The best results were obtained when the stains were ground to pass a No. 200 sieve after calcination. In large scale production where it would be important to minimize the work of grinding and sieving, a sieve with larger openings might prove satisfactory in many cases.

Removal of soluble matter from the calcined stains by washing with hot water, which was decanted off after settling was complete, tended to prevent a spotted appearance of the fired enamels. This treatment was especially helpful with the selenium-red stains.

The time and temperature of calcination of the stains, and the furnace atmosphere as affected by the adjustment of the gas flame, had to be duplicated in order to duplicate the shade of color obtained with a given batch composition. Adjustment of the flame did not enter into the preparation of the red stains, since they were calcined in an electric furnace; but the selenium-red stains were especially sensitive to variations in time and temperature of calcination. There was nothing to indicate that the relatively long calcination periods, which it was convenient to use in this laboratory work for all except the red stains, could not be considerably shortened if desired for large scale production. The practice of introducing the raw batch into a hot furnace, as in the case of the red stains, might be applied to shorten the time required for calcination of the other stains, in which case adjustments of the batch compositions and temperatures of calcination might become desirable.

Opacifiers introduced either in the raw batch or in the mill batch generally tended to lighten the color produced by a given stain. Some opacifying materials, however, probably due to chemical reaction, had a counteracting tendency to darken the shade. For instance, cryolite and fluorspar in the frit had little effect on the shades obtained except a slight lightening of tone, as would be expected from their power to opacify the enamel. Sodium antimonate, on the other hand, produced a darker tone in spite of its tendency to opacify the enamel.

Substitutions of silica and feldspar in the batch, one for the other, produced little effect on the resulting shades, except that (*a*) in the presence of zinc oxide an increase of silica at the expense of feldspar resulted in a darker shade, and (*b*) the tendency of sodium antimonate to produce a dark shade was accentuated by the substitution of silica for feldspar.

Lead oxide in the frit had a distinct tendency to darken the shade obtained with a given stain, an effect which was quite noticeable with the red stains.

The most salient factors in the duplication of colors may be summarized in the statements that: (*a*) the selenium-red stains were most sensitive to variations both in the procedure of their preparation and in the composition of the enamel frit, and (*b*) that lead oxide in the enamel frit had the most marked effect of any of the ingredients studied.

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NOTES ON CYANITE AND DIASPOR REFRACTORIES[1]

By E. J. Vachuska[2] and G. A. Bole[3]

ABSTRACT

This investigation covers a survey of some cyanite, diaspor, and clay refractories. The work is divided into three phases: (1) diaspor-cyanite study, (2) diaspor-clay and cyanite-clay study, and (3) commercial production and tests. Results of routine tests made with each set of test specimens are given. The addition of 20% or more cyanite to diaspor tends to counteract the shrinkage of diaspor during continued use at high temperatures.

Introduction

In the investigation "Cyanite-clay Refractories," Harrison[4] reported results on mixtures of cyanite and several types of clays. As diaspor clay was not included in the work and refractories containing it as a major constituent are coming into considerable importance in the commercial field, this investigation of various mixtures of diaspor and cyanite was undertaken.

Diaspor refractories have established themselves rather firmly in certain services although their general use is somewhat limited because of the permanent shrinkage which they exhibit upon prolonged subjection to high temperatures.[5] This volume change has generally been attributed to an inversion of the diaspor to alpha corundum, which change is accompanied by an increase in specific gravity (3.3 to 4.0). Attempts have been made to reduce this "after-shrinkage" by a high temperature calcination of the diaspor with a flux[6] which is said to be a catalyzer for the transformation of diaspor to beta instead of alpha corundum.

An attempt was made by the authors to produce a mullite structure in a diaspor-cyanite body by using a series of mixtures made up with various grades of raw material varying in their silica-alumina ratios. In the materials used, the silica was present almost entirely in the clay substance of the diaspor and as free quartz in the cyanite. It was impossible to obtain a homogeneous structure, even after a cone 26 treatment, except by the use of a flux. Due to the development of a large amount of glass when a flux was used, the physical properties of the resulting brick were unsatisfactory for most purposes.

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[1] Published by permission of the Director, National Bureau of Standards. Work done previous to transfer of Ceramic Experiment Station, U. S. Bureau of Mines. Received July 16, 1927.

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[4] *Jour. Amer. Ceram. Soc.*, 9 [5], 257–78 (1926).

[5] *Ibid.*, 9 [10], 659–66 (1926).

[6] S. M. Phelps. Paper read at American Refractories Institute Meeting in New York City and at American Ceramic Society Meeting in Detroit.

TABLE I
CHEMICAL ANALYSIS OF MATERIALS USED

	Cyanite concentrate Virginia			Cyanite concentrate California			Diaspor clay			Fire clay	Ball clay	Kaolin	Talc
	A %	B %	C %	D %	E %	F %	A %	B %	C %	%	%	%	%
H_2O and ignition loss	0.3	0.4	0.1				5.1	14.6	14.4	12.0	14.3	14.7	3.8
SiO_2	47.3	37.3	40.5	43.5	44.3	49.0	17.3	7.1	19.4	47.0	61.3	46.6	60.5
Al_2O_3	49.8	59.9	57.2	52.4	46.0	45.8	68.8	73.1	61.3	38.3	22.5	35.5	0.4
Fe_2O_3	1.2	0.7	1.5	1.2	2.0	1.5	1.2	0.8	1.2	1.7	0.2	1.6	1.2
CaO	0.8	0.1	0.1				0.3	0.5				0.3	0.7
MgO	0.1		0.2				0.4	0.5		0.8	1.5	0.3	34.0
Alk.		0.3					2.0	0.9		0.3	.3		
TiO_2	0.9	1.2	0.7	0.8	0.5	0.6	4.0	2.4	2.2			1.3	
P_2O_5							0.4					0.1	
	100.4	99.9	100.3	97.9	92.8	96.9	99.5	99.9	98.5	100.1	100.1	100.4	100.6
Mineral Analysis													
Cyanite				79	95		90.5	83.2	73.0	72.7			
Quartz				18	2		7.2	12.7	17.3	22.1			
Accessory minerals				3	3		2.3	4.1	9.7	5.2			

The raw materials consisted of several grades of cyanite concentrate from a deposit near Pamplin, Va., two grades of a commercial grade California cyanite concentrate (calcined), three grades of Missouri diaspor, a Georgia kaolin, a Kentucky ball clay, a plastic Missouri fire clay, and Inyo talc.

The chemical analyses of all the raw materials are given in Table I. The analysis of diaspor A was at first questioned, due to the low loss on ignition given, but a double check of the value would seem to indicate a partial calcination of the material although it was supposed to be the raw rock. A microscopic examination seemed to bear out the idea of partial calcination.

Diaspor-Cyanite Study

As a preliminary study, the series of bodies outlined in Table II were made. Cyanite concentrate A and diaspor A were used (see Table I). Screen analyses of these materials are given in Table III. Parallel batches using both raw and calcined cyanite were prepared. The dry batches were thoroughly mixed by hand, wet, and allowed to

TABLE II

COMPOSITION OF BAR MIXES
(Diaspor-cyanite Series)

Mark	Diaspor clay A	Cyanite concentrate A	Al_2O_3-SiO_2 mol. ratio
	(%)	(%)	
0	100	0	1:0.438
5	95	5	1:0.467
10	90	10	1:0.511
20	80	20	1:0.604
30	70	30	1:0.730
40	60	40	1:0.813
50	50	50	1:0.917

TABLE III

SCREEN ANALYSIS OF MATERIALS USED IN BARS

Screen	Calcined cyanite concentrate A (%)	Raw cyanite concentrate A (%)	Diaspor clay A (%)
On 20			1.9
" 28			6.6
" 35			14.1
" 48			16.4
" 65	0.5	0.3	13.2
" 100	12.7	10.7	14.5
" 150	18.6	19.8	9.3
" 200	10.9	10.5	4.7
Through 200	57.3	58.7	19.3

TABLE IV*a*

RESULTS OF REHEAT TESTS

Mark	Cone fired to	Linear firing shrinkage	Reheat (linear shrinkage) (basis original fired length) Cone 26 to 30 for 10 hours	Reheat (linear shrinkage) (basis original fired length) Cone 30 to 32 for 4½ hours	Total shrinkage (basis dry length)
		%	%	%	%
0	12	−1.0	−6.6	−7.1	−7.1
0	16	−2.2	−4.1	−6.1	−5.97
0	20	−2.7	−3.1	−5.6	−5.45
0	28	−4.7	−2.1	−3.7	−3.53
5 K	12	−0.5	−0.4	−3.5	−3.5
5 K	16	−0.8	−0.5	−2.0	−2.0
5 K	20	−0.8	0.0	−1.5	−1.5
5 K	28	−2.0	0.0	−1.0	−1.0
10 K	12	−0.5	*0.5	−1.5	−1.5
10 K	16	−0.5	0.0	−2.0	−2.0
10 K	20	−0.2	−0.5	−2.0	−2.0
10 K	28	−0.5	−0.5	−2.6	−2.6
20 K	12	0.0	*1.0	−1.0	−1.0
20 K	16	*0.2	*0.5	−0.5	−0.5
20 K	20	*1.3	−0.5	−1.5	−1.5
20 K	28	*1.2	0.0	−1.0	−1.0
30 K	12	0.0	0.0	*0.5	*0.5
30 K	16	0.0	0.0	0.0	0.0
30 K	20	*1.3	−0.5	−1.5	−1.5
30 K	28	*0.5	0.0	−1.5	−1.5
40 K	12	0.0	0.0	−1.0	0.0
40 K	16	0.0	0.0	−2.0	−2.0
40 K	20	*0.8	−0.5	−2.5	−2.5
40 K	28	*0.2	−0.5	−2.5	−2.5
50 K	12	0.0	−0.5	−2.0	−2.0
50 K	16	−0.2	−1.0	−2.5	−2.5
50 K	20	*0.3	−1.5	−2.5	−2.5
50 K	28	−0.2	−1.5	−3.0	−3.0

− denotes contraction
* denotes expansion
K denotes calcined cyanite

TABLE IV*b*

RESULTS OF REHEAT TESTS

Mark	Cone fired to	Linear firing shrinkage	Reheat (linear shrinkage) (basis original fired length) Cone 28 to 30 for 10 hours	Reheat (linear shrinkage) (basis original fired length) Cone 30 to 32 for 4½ hours	Total shrinkage (basis dry length)
		%	%	%	%
0	12	−1.0	−6.6	−7.1	−7.1
0	16	−2.2	−4.1	−6.1	−5.97
0	20	−2.7	−3.1	−5.6	−5.45
0	28	−4.7	−2.1	−3.7	−3.53
5 R	12	0.0	0.0	−2.5	−2.5
5 R	16	−1.0	0.0	−2.0	−2.0
5 R	20	*0.5	−1.0	−2.5	−2.5
5 R	28	−0.2	−1.0	−3.0	−3.0
10 R	12	0.0	*1.0	−1.5	−1.5
10 R	16	*1.2	0.0	−2.0	−2.0
10 R	20	*0.8	0.0	−3.0	−3.0
10 R	28	*0.5	0.0	−2.0	−2.0
20 R	12	0.0	*2.0	*1.0	*1.0
20 R	16	*1.5	0.0	−1.0	−1.0
20 R	20	*2.3	0.0	−1.5	−1.5
20 R	28	*1.7	*0.5	−1.0	−1.0
30 R	12	*0.5	*2.5	*0.5	*0.5
30 R	16	0.0	0.0	−1.5	−1.5
30 R	20	*3.8	−0.5	−1.4	−1.4
30 R	28	*2.5	0.0	−1.0	−1.0
40 R	12	*0.7	*2.0	−2.5	−2.5
40 R	16	0.0	−1.5	−2.4	−2.4
40 R	20	*3.5	−1.9	−2.4	−2.5
40 R	28	*3.2	−1.5	−3.4	−3.5
50 R	12	*0.8	*2.0	−0.5	−0.5
50 R	16	*4.7	−1.0	−4.8	−5.0
50 R	20	*4.2	−1.4	−3.4	−3.5
50 R	28	*3.0	−1.0	−1.9	−2.0

−denotes contraction * denotes expansion
R denotes raw cyanite

TABLE V

POROSITIES OF BARS

Mark	Cone 12	Cone 16	Cone 20	Cone 28	Total change 12–28
	%	%	%	%	%
0	32.2	—	29.5	27.1	−5.1
5 K	31.2	32.4	33.0	31.5	+0.3
10 K	32.4	—	33.8	33.1	+0.7
20 K	32.6	—	33.6	33.4	+0.8
30 K	33.1	—	34.0	33.1	0.0
40 K	33.8	33.8	32.9	31.8	−2.0
50 K	33.9	—	32.4	33.0	0.0
5 R	32.5	33.4	33.5	31.7	−0.8
10 R	32.2	—	34.9	34.1	+1.9
20 R	32.1	35.1	35.5	35.5	+3.4
30 R	31.7	—	35.7	34.3	+2.6
40 R	32.5	—	35.5	34.3	+1.8
50 R	33.2	—	34.2	34.5	+1.3

stand overnight. They were then molded into bars and marked for shrinkage determinations.

Three bars of each body mix were fired to each of the following temperatures:

Cone 12 in 17½ hours
" 16 " 26½ "
" 20 " 21½ "
" 28 " 26 "

The bars containing no cyanite showed a very marked tendency to warp on firing but this tendency had practically disappeared with the addition of 10% or more cyanite.

After removal from the kiln, linear shrinkage, porosity, and modulus of rupture determinations were made. One bar of each mix from each firing temperature was then reheated to cone 28 in 16 hours and held at that temperature for 10 hours (this treatment brought cone 30 half down) and another bar of each was reheated to cone 30 in 24½ hours and held at that temperature for 4½ hours, starting cone 32. Due to the failure of the silica brick supporting the bars, the heat treatment of cone 30 was stopped before the intended 10 hours soaking treatment had been completed.

TABLE VI
MODULUS OF RUPTURE VALUES ON BARS
(Modulus of Rupture in inch-lbs.)

Mark	Cone			
	12	16	20	28
0	2500	—	3500	3200
5 K	2200	2300	2100	2700
10 K	1800	—	2200	2200
20 K	1700	—	1600	1700
30 K	1000	—	1900	2500
40 K	1200	1400	2400	3400
50 K	1000	—	2600	2600
5 R	2100	1100	2200	2300
10 R	2300	—	3700	2000
20 R	2900	1700	1900	1800
30 R	2000	—	2700	2500
40 R	1700	—	2800	2600
50 R	1300	—	1600	2600

The results of the reheat tests, porosities at the various temperatures, and modulus of rupture values on one bar of each mix at each temperature are given in Tables IV*a*, IV*b*, V, and VI respectively.

Diaspor-clay and Cyanite-clay Study

In order to confirm results obtained with the cyanite-diaspor bars, and to correlate them with data on somewhat similar mixes using different clays with cyanite or diaspor, the series of body mixes shown in Table VII was prepared in the laboratory and made up into standard-size brick.

The batches were weighed and dry mixed as thoroughly as possible by hand, wet, aged overnight, then dry pressed into brick using pressures varying from 650 to 700 pounds per square inch. It will be noted that MgO in the form of talc was added to two of the mixes.

TABLE VII
COMPOSITIONS OF EXPERIMENTAL BRICK MIXES

No.	Cyanite concentrate	Diaspor clay	Ball clay	Kaolin	Fire clay	Talc	Al_2O_3-SiO_2 mol. ratio
V1	80	0	0	20	0	0	1:1.332
V2	80	0	0	0	20	0	1:1.321
V3	0	100	0	0	0	0	1:0.162
V4	0	80	0	0	20	0	1:0.399
V5	0	80	20	0	0	0	1:0.483
V6	0	80	0	20	0	0	1:0.399
V7	0	97.8	0	0	0	2.2	1:0.197
V8	28	56	0	0	13	2.8	1:0.634
C*	80	0	0	0	20	0	1:1.186
K*	80	0	0	20	0	0	1:1.198
4DP**	50	50	0	0	0	0	1:1.41

** California cyanite concentrate used. See analysis in Table I (E and F)
* Cyanite concentrate B (Table I) used raw
All other mixes contain cyanite concentrate showing analysis C precalcined to cone 20 and held for 3 hours at that temperature

The condition of the brick in the dry state, and the moisture content based on dry weight are given in Table VIII. The raw concentrate used in bodies C and K was ground to pass a 65-mesh screen in order to counteract to some degree the swelling and shattering which accompany the inversion to mullite. These brick were fired to cone 23 in twenty-eight hours and held at that temperature for five hours. Ten and one-half hours were taken to bring the kiln from cone 7 to cone 14, during which period the inversion of cyanite to mullite takes place. Drying cracks opened up on all specimens of these two compositions but the brick remained very strong.

TABLE VIII
MOISTURE CONTENT OF EXPERIMENTAL BRICK
(Based on dry weight)

No.	Per cent moisture	Condition in dry state
V1	6.53	Fairly firm
V2	11.27	Crumbly
V3	8.15	Firm
V4	7.14	Firm
V5	10.13	Very firm
V6	9.08	Firm
V7	9.62	Firm
V8	9.01	Firm
C	9.86	Firm; shows cracks
K	10	Firm; shows cracks

The other mixes (Table VII) were fired to cone 12 in 24½ hours, soaking from cone 9. Linear shrinkage and porosity determinations were made on five bricks and three bricks were refired to cone 20 in 24

hours, soaking from cone 17. Linear shrinkage and porosity determinations were made on the refired brick and one brick of each mix was refired again to cone 30 in 24 hours and linear shrinkage and porosity determinations made again.

Comparison with Commercial Fire Brick

To obtain data comparable with commercial brick under an equally severe reheat test, six high grade clay bricks and two electrically fused mullite bricks were reheated to cone 30 with the experimental brick. Comparative data on porosity and linear shrinkage are shown in Table IX. The data on the experimental bricks after they had been refired to cone 20 are used as a basis for comparison with the data on the commercial brick as received. This procedure was thought to be more comparable with the commercial brick as the experimental brick could not be considered as of a satisfactory structure when fired to cone 12.

TABLE IX

POROSITY AND SHRINKAGE DETERMINATIONS ON EXPERIMENTAL AND COMMERCIAL BRICK

Brick	Cone 12		Cone 20		Cone 30		Decreased porosity C20–30
	Per cent total linear change	Per cent porosity	Per cent total linear change	Per cent porosity	Per cent total linear change	Per cent porosity	
V1	+1.3	42.3	+0.3	40.8	−2.3	36.2	4.6
V2	+1.3	43.7	+1.1	43.6	−2.7	37.4	6.2
V3	−2.2	42.0	−7.2	34.2	−17.3	8.9	25.3
V4	−2.9	39.8	−3.7	37.7	−8.5	29.6	7.9
V5	−3.2	39.6	−4.6	36.2	−11.7	20.4	15.8
V6	−3.1	40.7	−4.2	39.2	−12.1	24.5	14.7
V7	−6.7	38.8	−13.2	21.3	−15.3	1.9	19.6
V8	−0.6	39.9	−0.1	42.4	−5.4	29.7	12.7
C*	—	—	−3.5	33.0	−3.6	33.0	0.0
K*	—	—	−3.3	33.0	−3.4	33.0	0.0
M	High grade flint fireclay brick			23.8	−2.7	12.7	11.1
N	Medium aluminous brick			34.4	−1.5	27.3	7.1
O	Highly aluminous brick			21.6	−4.4	12.5	9.1
P	Diaspor brick			35.2	−6.9	19.3	15.9
Q	Flint fireclay brick			16.9	+0.5	9.7	7.2
R	Diaspor brick			34.2	−2.6	24.4	9.8
S	Mullite (fused) brick			22.6	0.0	20.7	1.9
T	Mullite (fused) brick			30.1	−0.1	30.3	0.2

NOTE: Cone 20 is taken as the proper firing temperature for the experimental brick and the length after that treatment is used as a basis for calculation. Minus sign in front of a shrinkage value indicates expansion

* These brick fired originally to cone 23 and the data for that temperature given

Spall tests were also run at 850°C according to the U. S. Government Master Specifications, on the brick fired to cones 20 and 30. Results for these tests are shown in Table X.

A load test in which the bricks were held at 1500°C for one and one-half hours under 25 pounds per square inch load, was made using brick refired to cone 20. The results are given in Table XI.

TABLE X
SPALLING BEHAVIOR OF EXPERIMENTAL AND COMMERCIAL BRICK

Brick	Cone 20		Cone 30	
	Cycles	Loss (%)	Cycles	Loss (%)
V1	30	26.6	9	27.3
V2	56	18.3	4	22.1
V3	49.5	24.2	2	26.8
V4	51.5	19.7	10	25.6
V5	48	21.1	7	30.3
V6	58	17.9	8	23.7
V7	3.5	27.1	1	50.4
V8	26.5	19.2	2	21.4
C**	81*	0.0		
K**	68*	19.4		
4DP	25.5			
M	High grade flint fireclay brick		4	18.5
N	Medium aluminous brick		12*	0.0
O	Highly aluminous brick		9	17.3
P	Diaspor brick		12	14.4
Q	Flint fireclay brick		1	13.5
R	Diaspor brick		4	20.3
S***	33	19.0	Mullite (fused) brick	
T***	41	22.6	Mullite (fused) brick	

* Test discontinued; indicates number of cycles reached
** Fired to cone 23
*** As received, not cone 20
NOTE: The brick below 4DP are high grade commercial brands

TABLE XI
RESULTS OF LOAD TEST

Brick	Per cent contraction (linear)	Condition
V1	4.7	Sheared
V2	7.7	Starting to shear
V3	3.5	Sheared
V4	7.2	Started to shear
V5	7.2	Sheared
V6	12.8	Good
V8	4.6	Sheared
Mullite (fused) brick	0.0	Sheared

Commercial Tests

In order to determine to some extent the practicability of commercial manufacture and use of the types of brick studied, a series of mixes was prepared and made up into brick and arch tile for boiler furnaces at a firebrick plant. The mixes are listed in Table XII.

The California cyanite concentrate was a commercial grade and contained about 15% free quartz as estimated petrographically. During the treatment given it before placing it on the market, this cyanite concentrate was only superficially converted to mullite and the product contained approximately 5% of a glass which seemed to have no relation whatever to the other minerals present. California cyanite was used in 2 mesh-sizes. Material designated as "fine" passed 80-mesh screen while the "coarse" passed 10-mesh and was retained on a 40-mesh screen.

The Virginia cyanite was a low-grade concentrate containing much quartz. It was tried out in preference to the high-grade material

TABLE XII

COMPOSITION OF BRICK AND ARCH TILE MADE BY COMMERCIAL PROCESSES

Mixes	
No. 1	5.0% calcined cyanite concentrate F{50% fine California; E{50% coarse " 95.0% raw diaspor C
No. 2	10.0% calcined cyanite concentrate F{50% fine California; E{50% coarse " 90.0% raw diaspor C
No. 3	33.0% calcined cyanite concentrate F{50% fine California; E{50% coarse " 67.0% diaspor C
No. 4	50.0% calcined cyanite concentrate F{50% fine California; E{50% coarse " 50.0% raw diaspor C
No. 4DP	Made up dry press
No. 4A	50.0% calcined cyanite concentrate D Virginia (through 48-mesh) 50% diaspor C
No. 5	49.0% calcined cyanite concentrate F{50% fine California; E{50% coarse " 49.0% raw diaspor C 2.0% talc (raw)
No. 6	80.0% calcined cyanite concentrate F{50% fine California; E{50% coarse " 20.0% raw diaspor C
No. 6A	Same as No. 6 made dry press
No. 7	Same as No. 6 plus bond of 5% commercial sulphite liquor solution
No. 8	Same as No. 6 plus bond of 1% lithium chloride solution
No. 8A	Same as No. 6 plus bond of 2% lithium chloride solution
No. 9	5.0% raw cyanite concentrate D (coarse Virginia) 95.0% raw diaspor C
No. 10	33.0% raw cyanite concentrate D (coarse Virginia) 67.0% raw diaspor C
No. 11	16.5% raw cyanite concentrate D (fine Virginia) 16.5% calcined cyanite concentrate D (fine Virginia) 67.0% raw diaspor C
No. 11A	Same as No. 11 but used Virginia −20 mesh calcined cyanite D instead of −30-mesh calcined concentrate D
No. 12	5.0% raw cyanite concentrate D Virginia (coarse and fine mixed) 5.0% calcined cyanite concentrate D (coarse Virginia) 90.0% raw diaspor C
No. 13	10.0% calcined cyanite concentrate D (coarse Virginia) 40.0% calcined diaspor C {(75% calcined to cone 30; {(25% calcined to cone 18 50.0% raw diaspor C
No. 13A	Same as No. 13 made dry press
No. 14	5.0% calcined cyanite concentrate D (coarse Virginia) 5.0% raw cyanite concentrate D Virginia (coarse and fine mixed) 40.0% calcined diaspor C {75% calcined to cone 30; {25% calcined to cone 18 50.0% raw diaspor C (8 mesh)
No. 15	Same as No. 14 plus bond of 2% lithium chloride solution; used diaspor C calcined to cone 18 (8-mesh)
No. 16	Same as No. 14 plus bond of 5% commercial sulphite liquor; used diaspor C calcined to cone 18
No. 17	20.0% calcined cyanite concentrate D Virginia (through 40-mesh) 20.0% raw cyanite concentrate D Virginia (coarse and fine mixed) 60.0% raw diaspor C
No. 18	40.0% calcined diaspor C fused with 1% talc 30.0% calcined cyanite concentrate F{50% California; E{50% −10–40-mesh Calif. 30.0% raw diaspor C
No. 18A	Same as No. 18 with calcined diaspor C fused with 3% talc
No. 18B	Same as No. 18 with calcined diaspor C fused with 5% talc

because it can be produced quite cheaply. Virginia cyanite also came in 2 mesh-sizes. Material designated as "coarse" entirely passed a 30-mesh screen while the "fine" passed a 70-mesh screen.

The materials were mixed dry by rolling in a barrel mixer, ground in a wet pan to the desired consistency, aged for 48 hours, and made into brick and arch tile (for boiler arches) by hand molding except where otherwise indicated. The lithium chloride gave a slight advantage at the higher concentration.

In an endeavor to increase the green bond, a commercial sulphite liquor was used at two dilutions. As Bancroft[1] reports enormous increases in the bond of clays due to the use of a small percentage of lithium chloride solution, this salt was tried at two dilutions as indicated in Table XII. The commercial sulphite liquor was an actual detriment at the higher concentrations as it produced a "case hardened" surface which inhibited drying and caused cracking.

Owing to the fact that practically all of the mixes made into arch tile cracked on drying, they were reground and mixed with 20% of a plastic fire clay. The exceptions to this procedure were mixes Nos. 6, 7, 8, 8*a*, 12, 16, and 18*b* of the hand-molded brick and all those made by the dry press method.

The average moisture content of the mixes used for hand molding was 18% of the weight of the dry material while in the case of the dry press mixes it was 10%.

TABLE XIII

AVERAGE POROSITY AND VOLUME CHANGE OF BRICK MADE BY COMMERCIAL PROCESSES

No.	Porosity		Volume change
	As received (cone 12) %	Refired to cone 20 %	%
1	34.5	28.4	+0.3
2	33.7	31.7	−1.0
3	35.1	32.5	−0.9
4DP	37.1	35.0	−2.7
4A	30.6	27.8	−0.1
5	31.1	25.4	−6.4
6	40.3	36.8	−2.5
7	31.7	28.1	−3.1
9	35.6	31.1	−4.5
10	38.5	35.6	+0.5
11	36.7	33.1	−5.1
11A	36.3	31.8	+0.4
12	39.7	36.2	−6.6
13HM	33.8		
13DP	40.0	38.0	−3.2
14	36.5	36.2	−5.8
15	35.3	32.0	−3.9
17	40.3	34.8	+0.7
18	34.5	32.3	−2.0
18B	32.7	31.5	−0.5

[1] W. D. Bancroft and L. E. Jenks, *Jour. Phys. Chem.*, **29** [10], 1215–16 (1925); *Ceram. Abs.*, **5** [2], 65 (1926).,

The ware was dried on a hot floor and fired in a round downdraft commercial firebrick kiln to cone 12 in four days. Inasmuch as the firing temperature was not high enough to fully mature a cyanite-diaspor refractory, the porosity of the brick was determined as received at Columbus and then again after firing to cone 20 in 48 hours. A comparison of the porosities and volume change of the brick before and after refiring is shown in Table XIII.

Load tests at 1500°C for 1½ hours, 25 pounds per square inch load, gave the following results:

Mix No.	Per cent contraction	Remarks
4	3.3	O.K.
4[a]	2.6	Started to shear
5	3.1	" " "
11	none	O.K.
13	0.7	O.K.
15	0.4	O.K.

Sets of five bricks of each of mixes Nos. 4, 6, and 13 were given a service test in the bung of an air furnace at a malleable iron plant. This test was simply a commercial spalling test as there was no expectation that the brick would withstand the service conditions imposed on them as the batches made up for these tests were high in free quartz. Brick of mixes 6 and 13 withstood eight heats while those of mix 4 withstood six heats before being spalled enough to necessitate replacement. In each case the spalling took place while the furnace was cooling overnight rather than while heat was being applied to the brick. At the time of removal the spalling had caused the loss of a portion of the brick somewhat in excess of that lost in the case of the fire brick in actual use at the plant.

FIG. 1.—Tiles 7 and 9 after 14 days' service in arch of boiler setting. Tile in rear is an unused standard tile for comparison. For service rendered by fireclay tile under same conditions, see Fig. 2.

Arch tile were placed in the main arch of a boiler furnace two courses back of the nose block. The boiler was fired with Illinois coal on chain-grate stokers. The service of the test tile as compared with a high grade commercial flint fireclay tile was very carefully observed and recorded by representatives of the Bureau of Mines working at the plant at the time. The test was continued over a period of fourteen days. Tiles 7 and 9 held up quite well as will be seen in Fig. 1 where they are compared with a fireclay tile under identical conditions. Tile 8 gave poor service due to extreme spalling (see Fig. 2).

These tile, as stated above, were fired to cone 12. This treatment produced so weak a structure that a major portion of the spall effect was really due to a pinch caused by a lateral thrust from adjacent tile which the specimens could not resist, due to low mechanical strength.

General Observations

In searching for an explanation of the fact that bodies 20 K, 30 K, 20 R, and 30 R (cyanite-diaspor series) show practically no volume change from the green state to a heat treatment where silica brick failed, it was noted that a composite analysis of these mixes showed 20 K and 20 R to be near the mullite ratio with alumina in excess, while 30 K and 30 R showed silica in slight excess over the mullite ratio. It could not be expected, however, that the final mineral constitution of these mixes would be as indicated by the composite analyses since there is not a stable equilibrium established which embraces the entire mix composition. A more reasonable possibility would be that there are two separate systems in metastable equilibrium, the one with the other, (1) cyanite dissociating into mullite and silica glass, and (2) diaspor clay being converted into mullite, alpha, and possibly beta corundum. If these possibilities are true it would be comparatively easy to see why there is so little volume change in the bars. Due to the finely crystalline character of the material, exact optical properties of the constituents present could not be determined and conclusive statements regarding what did occur to produce the results obtained are not justified.

FIG. 2.—Tile 8 (left) compared with fireclay tile (right) under identical conditions of service. Tile in rear are standard unused tile.

No very marked changes in porosity were observed in any of the diaspor-cyanite mixes containing calcined cyanite. The total change from cone 12 to cone 28 in the bars made up with raw cyanite was slightly greater than that of the calcined cyanite mixes but less than in the straight diaspor.

It is interesting to note that in a majority of the cases the porosity increased at cone 20 as compared with cone 12 but decreased again at cone 28.

From the standpoint of resistance to spalling it appears that the addition of cyanite to diaspor is less beneficial than is the addition of cyanite to clay and that, of the two sets of cyanite-clay mixes, those containing raw cyanite seem to show the better resistance to spalling.

However, due to several contributing factors, no final conclusions can be drawn. Among these factors are the facts that (1) the raw cyanite was of a higher grade than the calcined, being 95% cyanite with 2% quartz, as against 90.5% cyanite with 7.2% quartz; (2) the raw cyanite-clay brick were fired to a higher temperature (cone 23 as against cone 20) and showed a lower porosity; and (3) the drying or pressing cracks in the raw cyanite specimens may have tended to relieve the strains set up in the brick in the spalling treatment.

A microscopic study of a number of these brick indicated that the brick with the most homogeneous structure were least resistant to spalling. This was doubtless caused by the fact that there was in each case considerable glass present due to the flux used. Although the grains of cyanite after firing contain considerable high silica glass, they appear to function as pure mullite due to the structure set up.

Precalcination of the diaspor largely overcomes the shrinkage of bricks of which it is a constituent. The higher the temperature of calcination the higher can be the temperature to which the bricks may be subjected with no marked shrinkage.

The addition of talc to diaspor speeds up the rate of shrinkage so as to bring the total shrinkage nearly to completion in a considerably shorter time and at a lower temperature than would otherwise be the case. It is, however, detrimental from the standpoint of resistance to spalling.

The work so far does show that more investigation is necessary and the data is presented with the idea that it will serve as a help if not a basis for further research.

DESIGN AND SERVICE OF TANK BLOCKS[1]

By Donald W. Ross

ABSTRACT

Data are presented and some inferences are drawn concerning the manner in which properties of the tank blocks, their use and design, and the design of the tank itself, affect the life of the tank.

Cracking

Shrinkage cracking of the interior face of the blocks during heating up and use has been covered elsewhere.[2]

The fact, the importance of which has been frequently overlooked, is that during the heating up and early life of tanks many of the blocks crack entirely through. These cracks are plainly visible on the outside of the tank while it is in operation and their disastrous effects to the inside of the tank are apparent after the tank has been emptied.

Heating Blocks Observation of a number of cases inclines us to the opinion that the breaking of tank blocks during the heating of tanks, is frequently caused by pressure arising from expansion of the blocks against their supports, and that breaking from purely thermal causes occurs principally between 800°F and glass melting temperatures, instead of at lower temperatures.

The following may be an approximate picture of what happens. Assume that as the tank is heated, the inner face of the block expands, while the outside of the block changes but little, so that the inner surface of the block is under compression and the outside is under tension. The strain in the block will thus increase up to the point at which the face of the block begins to soften, above which temperature the strain, at and near the face, might be expected to be relieved.

On the basis of this assumption it would appear permissible to heat tanks rather rapidly at low temperatures, while it would appear highly desirable to carefully avoid thermal shock at higher temperatures, such as, above 800°F. This view also suggests the idea that thick side-walls might be expected to heat up more safely than thin ones.

Cracking and Floating Out The cracking of blocks is at times as disastrous as their solution by the glass, for when the block is gone it usually makes little difference whether it has been dissolved or floated away. (Fig. 1).

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Glass Division.)

[2] F. C. Flint and A. R. Payne, "Tank Block Corrosion by Shelving," *Jour. Amer. Ceram. Soc.*, 9 [9], 631 (1926). Donald W. Ross, "Wearing away of Tank Blocks," *Jour. Amer. Ceram. Soc.*, 9 [10], 641 (1926).

Horizontal Cracks In case pieces of the blocks do not float out, the horizontal portions of the cracks give access for penetration of glass with resultant rapid upward eating. Figure 2 shows such a crack.

Cracking and Thickness Figure 3 represents the two side walls of the melting chamber of a tank. These blocks were all made within a few days of each other and from the same batch of clay. They were all fired in the same kiln at the same time, and the different sizes of blocks were intermixed in the kiln. The left side of the tank consisted of a 12-inch thick wall while the right side consisted of 8-inch thick blocks. As is the case with most blocks in service, cracks were present in these blocks during the early life of the tank. After the tank had been drained the left side was in good condition, and except at the metal line and the bottom, was still considerably over eight inches thick, while there were many steplike cavities in the right hand wall, and at places the glass had eaten entirely through the blocks. Examination of these blocks showed that the steplike cavities extended upward from horizontal cracks, which were apparent on the outside of the tank during service. This tank was let out on account of the failure of the eight-inch wall. Hence, in this case it seems fair to assume that the eight-inch blocks yielded less service per inch of thickness than the twelve-inch blocks would have eventually yielded had they been used to their limit. Also, as in the previous case (Figs. 1 and 2), this type of failure is associated with cracks which were visible on the outside of the tank during operation.[1]

FIG. 1.

FIG. 2.

These three instances illustrate the troubles that may arise from cracking of tank blocks early in the tank's life. Such cracks probably

[1] See also D. W. Ross, *loc. cit.*

could be avoided if tanks were brought up without rapid changes of temperature. However under existing conditions rapid changes of temperature are common, hence this problem is one for both the block manufacturer and the glass manufacturer to consider.

Metal Line Attack

Figure 4 shows the nature of attack at the metal line of tanks. General observations appear to indicate that in the case of tanks operated at relatively low temperatures and with no salt cake in the glass batch, blocks that serve exceptionally well below the glass line also do exceptionally well at the metal line. However at the present time tanks are quite generally operated at relatively high temperatures, and in the last three years the use of a small percentage of salt cake to prevent scum on top of the glass has become quite common. The present result of these changes is, that at the metal line, blocks are apparently dissolved faster, relative to the rest of the block. Likewise there is less difference in wear at the metal line of the average and of the exceptional blocks.

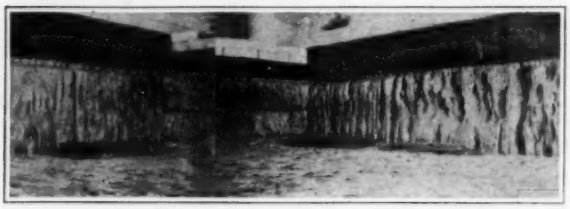

FIG. 3.

It is not yet apparent exactly what percentage of this increased eating at the metal line is due to increased temperature. It appears probable that, small as is the percentage of salt cake used, the amount is in excess of that required for scum prevention, and that the excess attacks the blocks at the metal line. It therefore appears probable that action on the blocks at the metal line of tanks, would be decreased by decreasing the amount of salt cake.

FIG. 4.

Secondary Metal Line The sloping shape of blocks immediately below the metal line, as shown in Fig. 4 suggests that in case the blocks are still in good condition below the metal line a lowering of the glass level two inches will bring a second metal line at a place where the blocks are still relatively thick. Pro-

viding there is no failure in other parts of the tank such lowering of the glass level increases the tank life. In fact in cases where tank failure regularly occurs at the metal line, it appears that it would be profitable to provide (in conjunction with glass feeders) for such a secondary metal line.

It thus appears that we can gain in service at the metal line by using as little salt cake as may be necessary and by use of a secondary metal line late in the life of the tank.

Flow-Hole Attack

Depth over Flow Hole

Figure 5 shows the manner in which the blocks adjoining the flow hole of a bridge wall are eaten. The main action on the blocks by the glass flowing through the flow hole has apparently been to cut a channel vertically upward, while on each side of this channel the effects of upward eating (as described elsewhere)[1] are apparent. As shown by Fig. 6 the eating at the horizontal joints is least between the bottom blocks and the lower course of the bridge, more between the first and second courses, and greatest at the uppermost horizontal joint. It is plain that the life of a bridge is dependent on the amount of wear required for the glass to cut a channel up to the wind-line opening, and for upward eating from horizontal joints to do its work. From this it is easy to conclude that bridge service would be increased by increasing the vertical thickness of block between the flow hole and the wind chamber, and by elimination of horizontal joints in the bridge.

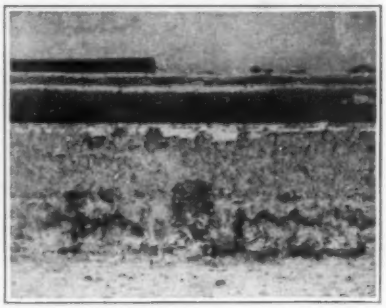

FIG. 5.

Bridge Construction

Common Bridge

Many tanks fail through failure of the bridge or throat. It appears that there may be some better device than a bridge or throat for this purpose, or if we prefer to use a bridge or throat, that the design can be improved.

Several types of design suggest themselves. Thus Fig. 7 (upper left) shows an ordinary type of bridge with horizontal joints.

This type has the defects noted in Figs. 5 and 6. It has the advantage that but a single block covers the flow hole and hence there are no vertical joints across the flow hole. However, the thickness of block

[1] D. W. Ross, *loc. cit.*

over the flow hole in this type is only approximately twelve or fourteen inches.

"Acme" Throat A throat of this general type commonly known as the acme throat is shown in Fig. 7 (upper center).

Bridge vs. Throats Glass men do not agree on whether a bridge tank, or throat tank, is the better form. In the throat type, failures usually come only at or near the flow hole and may be held in check by water boxes or "overcoat blocks" (blocks placed over the danger zone). If actual failure in the throat type does take place the glass goes into the basement under the tank.

FIG. 6.

In the bridge type tank, eating through may occur at any point across the width of the tank, but even after the lower part of the bridge wall has largely disappeared a water pipe through the air chamber may be maintained and glass frozen around it so as to act as a skimmer and the tank continued in operation for a considerable period. When the water pipe finally does break, there is merely a disturbance within the tank, without putting glass into the basement.

Three-piece Notched Throat In Fig. 7 (upper right), is shown another type of throat, in which there are no horizontal joints. This consists of but three flux blocks, all three of which are special. In this type the two outside blocks are notched supposedly to hold the central block in place. However in practice the glass chilling around the edges of the joints usually prevents upward movement of this block. The offset caused by the notches in the outer blocks serve to form vertical "concealed" joints between them and the central block, where these joints come into contact with the adjoining blocks of the tank. These hot joints apparently aid in keeping the glass more or less fluid in the joints between the outside blocks and the central block, for in this type of throat, glass frequently leaks out under the notch.

Three-piece Throat Rectangular Blocks Figure 7 (lower left), shows a similar type in which the notches and concealed vertical joints are eliminated. Figure 7 (lower center), shows a similar type, in which however, the refining end wall is simply a rectangular block with a notch in it. Figure 7 (lower right), shows a throat type similar to that of previous figure, except that it has a sunken

flow hole in which case the blocks are all rectangular and are therefore somewhat simpler to make. However even in this type, there are two vertical joints across the flow hole. In the past, the central block of this type of throat has usually been longer than the melting and refining end blocks as is shown in Fig. 7 (lower right). However in modern practice the central block is made shorter than the other two blocks, thus avoiding four vertical concealed joints.

Two-piece Throat Figure 8 shows a two-piece throat, in which there is but one vertical joint across the flow hole. For convenience the throat blocks are shown at the right. These belong in the position shown by the rectangle over the sunken flow hole shown at the left.

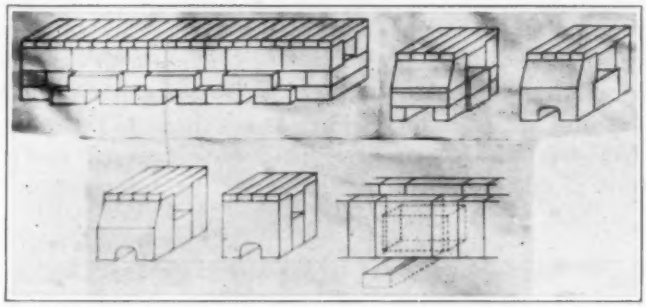

FIG. 7.

Sunken throats permit of greater depth of block over the flow hole with the result that a greater amount of wear is required before the glass reaches the air passage.

One-piece Throat In Fig. 10 (upper left), is shown a one-piece throat of the same general dimensions as that shown in Fig. 8. Such a tank block is larger than is usually used in present day practice, 36 by 48 by 48 inches.

As is outlined above and as mentioned elsewhere[1] it appears quite possible that a throat is eaten upward rapidly primarily because the products of reaction of glass and block are swept away from such a downward-facing surface substantially as fast as formed, and that hence the thickness of the throat wall between the melting and refining ends is of little moment. If this be true we might reasonably expect that a one-piece throat of lesser thickness than that shown in Fig. 10 (upper left), would give satisfactory service.

Reducing the thickness of a block such as that shown in Fig. 10 (lower right), between melting and refining ends, would serve substantially to reduce its weight.

[1] D. W. Ross, *loc. cit.*

Spray Cooling As shown, there are two horizontal passageways through the bridge one above the other, in place of the usual single air passage. These are intercepted by vertical passages at the joints between the blocks. Instead of water being pumped through these passageways in iron containers, or lying as a lake within them, the water is merely sprayed into the bare chamber, and is introduced to prevent the chamber from becoming too hot, the latent heat of vaporization serving to maintain the chambers at suitable working temperatures.

As the cracking of tank blocks during the "bringing up" of the tank is probably largely dependent upon the drop in temperature through the block, such water cooling of the block may preferably be deferred until any desired time in the tank's life. So that there will not be too great a thermal shock on introduction of water, the water may preferably be preceded by steam for a suitable length of time. To minimize the trouble caused by "caking" of sediment in the pipes such steam and water may be introduced through the pipes in the vertical channels which can periodically be removed and renewed. Such a type of cooling is recommended by the great saving it would effect in amount of cooling water.

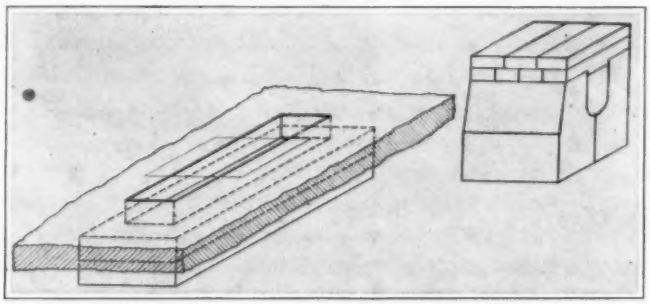

FIG. 8.

Cooling of the lower horizontal passageway may serve to retard upward eating at the flow holes, while cooling the upper passage should serve to retard eating at the metal line.

Of course these blocks as shown in Fig. 10 (lower right), would normally be overlain by cover blocks as bridges generally are.

String and Seeds It has been quite common practice to use water in pipe lines through bridges after the bridges have become old, and to place water boxes around throats of throat type tanks as they become old. The relatively large amount of cord and occasional batches of seeds occurring in tanks that are being thus maintained, suggests the probability that glass congeals adjacent to the

iron surfaces, that gobs of this partially congealed glass are occasionally pulled away by the stream of glass and are mixed with it and swept on out of the tank and into ware. It would thus appear to be better to have a block wall against rapidly moving glass, which is continuously swept clean, than a wall consisting of congealed glass. The congealing of glass in contact with water boxes as compared to blocks backed by over-coat blocks is shown in Fig. 9.

FIG. 9.—White mass against right hand wall of tank shows where tank was repaired by water box, which froze gobs of glass to it. The balance of the right side of the tank was backed by "over-coat" blocks and shows a smooth surface.

Water in direct contact with the block serves to prevent glass getting through the bridge at vertical joints, and to maintain a smooth wearing block surface in contact with the glass passing through the flow hole.

Water in direct contact with blocks, as would be the practice with this type of bridge, should therefore prove a better means of maintaining bridges in service, than is the present practice of using the water in iron containers.

Multiple Sunken Flow-hole Bridge

The type of bridge just discussed involves several new features. In Fig. 11 is a type of bridge, which although somewhat different from the usual bridge, involves no untried features. Several views are shown here, so as to accentuate the various features.

Its Wearing Properties

The flow hole covers in this type of bridge consist of two blocks. Thus if one of these blocks cracks through, the other one prevents glass getting through from the melting to the refining end. The joints between the melting end blocks are staggered with those between the refining end blocks, thus insuring that glass will not find its way through the bridge between the blocks. The sunken flow holes permit of an unusual depth of block over the flow holes. The air passage is of such type that the spray system of cooling, as described above, may be used if desired, late in the life of the tank to maintain the tank in operation. The slope of the face of the blocks

in the melting end perhaps tends to retard the flow of clay-laden glass from them and thus decreases their rate of solution in the glass.

Glass Flow Glass men are perhaps not all agreed as to the exact manner of travel of glass from the back end of tanks to the bridge or throat. However, it appears possible that the more numerous the flow holes are, and the closer their tops are to the tank floor level, the more general, or more nearly uniform, will be the movement in the glass at cross-sections of the tank near the bridge.[1]

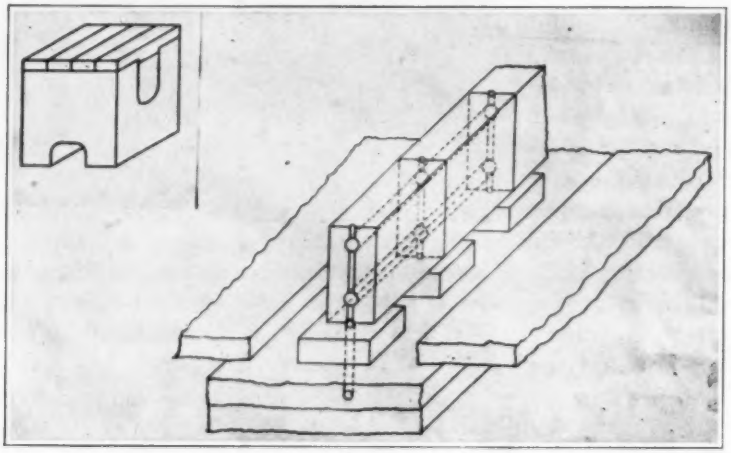

FIG. 10.

Stream Prevention We might expect then that with the "multiple flowhole" type of bridge here shown, with its "settling basin" effect on the melting side of the bridge, stream formation would be more or less prevented, which in turn might be expected to tend to prevent formation of cords and increase the melting capacity of the tank. The similar form of "off take," on the refining side of such a bridge, should tend to insure a uniform distribution of glass, into the refining end, across the width of the tank.

Travel through Flow Hole Through continual thinking of the travel of glass through flow holes in terms of stream formation, and observation of the effects on the blocks that

[1] G. V. McCauley of the Corning Glass Works has stated the view that glass circulates forward to the bridge and then descends, and that likewise glass descends at the sides of the tank (ends of the bridge); and that hence the entrance to sunken flow holes should extend along the bridge, but need not extend very far into the melting end from the bridge. Such a construction tends to draw glass from the entire cross-section of the tank. Further, the glass traveling through sunken flow holes is sufficiently cool so that it spreads out under the hot surface glass and only gradually rises to the surface, thus avoiding the formation of hot streams in the glass. Privately communicated.

cover the flow holes, we might come to the conclusion that, in service, glass flows relatively fast in the upper part of the flow hole and very slowly or practically not at all near the floor of the flow hole. However, observation of such floor blocks under flow holes after a tank has been let out indicates that frequently these blocks have been swept quite clean and defects in their surface have been well scoured out.

Insulating Flow Hole

Following this latter view it appears possible that if the floor of such a bridge were insulated by being underlain by another thickness of flux blocks, such insulation of the glass stream might tend to equalize the rate of flow over the entire area of the flow hole instead of concentrating the glass flow near its top.

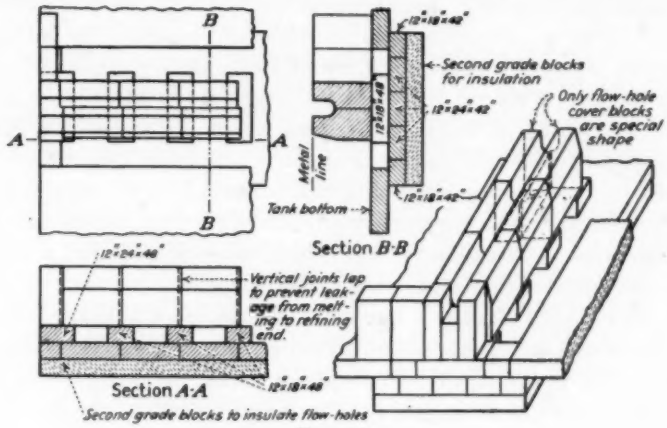

FIG. 11.

Blocks Floating Up

Relatively small bottom blocks, if thus insulated in the floor might tend to become loosened and float up. However, if moderately large blocks are used they can be suitably tied down by the other parts of the bridge. There is, however, one more thing to be considered in this connection and that is that such floor blocks must have a close hard-fired structure; otherwise, in service, they are apt to shrink, crack, and float up in pieces.

Summary

We have herein described some ways in which tank blocks are deteriorated, and have set forth several features pertaining to throat and bridge wall design.

As noted in this paper some of the features presented are perhaps somewhat novel, hence it is hoped that comment, either favorable or unfavorable, will be forthcoming.

FINDLAY CLAY POT COMPANY
WASHINGTON, PA.

SPALLING AND LOSS IN COMPRESSIVE STRENGTH OF FIRE BRICK[1]

By Hobert R. Goodrich

ABSTRACT

A preliminary report of the loss of compressive strength when fireclay brick from the Pacific Northwest were subjected to a series of heat treatments to 1350° and 1250°C. It illustrates some of the variations of heat treatment in the manufacturer's kilns and the differences between the high siliceous type of fire brick and the vitrifying clay type with lower free silica content. It is possible that a satisfactory spalling test may be developed in this direction.

Definition of Spalling

While spalling is a term commonly used throughout the stone and mining industries to describe the operation of chipping the surface or edges of stone by artificial means, when employed by the manufacturers and users of fire brick, it denotes the crumbling, "slabbing-off," or disintegration which a brick undergoes when subjected to furnace conditions and thermal shock. Such disintegration is brought about by one or both of two causes, one being the difference in temperature, and hence in the degree of expansion or contraction of the inner and outer faces of the brick, and the other being a difference in the expansion of the component particles of the brick, such as might occur with a mixture of quartz and clay particles. The characteristics of a spalled brick is a general loosened condition of the structure, accompanied by cracking and even by the breaking off of corners or faces. The degree to which the brick is weakened is shown by the tests described herein.

Importance of Spalling Tests

The increased use of oil, powdered fuel, and gas in all types of heating devices has brought about a larger demand for fire brick capable of sustaining the severe thermal shocks produced by the sudden blasts of hot flames on the brick work of the fire box. Thermal shocks are not, however, limited to fire boxes alone, but have also to be combatted by the brick composing the walls of reverberatories, melting ovens, coke-oven retorts, and various other places where cold charges of ore, fuel, or fluxes are suddenly brought into contact with hot fire brick.

Among the various types of fire brick, the fireclay brick have always taken a leading place in resisting these thermal shocks. It is imperative for the manufacturer of fireclay brick to develop in his product a greater resistance to spalling, along with the other necessary qualities, such as refractoriness, resistance to slagging and to loads at high temperatures.

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[1] From a thesis submitted for the degree of Bachelor of Science in Ceramic Engineering, University of Washington, Seattle. Received February 23, 1927.

Review of Spalling Tests

Tentative Test of the A.S.T.M.

The American Society for Testing Materials has a tentative method of testing the spalling resistance of fireclay brick.[1-2] In this test, five brick are heated to a temperature of 1400°C, maintained at this temperature for five hours, and cooled. The brick are then weighed and placed in the door of a furnace operated at 1350°C, care being taken to prevent the direct heating of more than one end of the brick. After one hour, the specimen is withdrawn and stood on end in a tank of flowing cold water so that the hot end will be immersed to a depth of four inches. After three minutes, the brick is withdrawn and allowed to steam for five minutes and is then returned to the furnace. This plan of alternate heating and cooling is continued until the end of the brick spalls off.

When pieces begin to spall off, the sample is laid on a 4.5- by 9.0-inch asbestos board which is divided into 100 equal squares, and the approximate percentage of loss is estimated after each removal from the water. After the completion of the test, the brick is again weighed and the percentage of loss determined.

As an alternative to water-cooling, an air blast may be used.

The final report shows the number of dips before the loss started, the percentage of loss after each cooling, the total number of dips, and the final percentage of loss by weight.

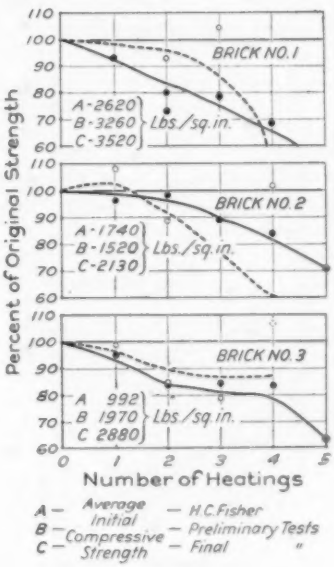

FIG. 1.

The United States Government Master Specifications

In the master specifications of the United States government, fireclay brick are divided into classes, and spalling is taken as one of the indices of the class to which a brick belongs.[3] For very severe use such as in navy boilers, the brick are subjected to the "Simulative Service Test," which is next described. Otherwise, they

[1] C. E. Nesbitt and M. L. Bell, "Methods of Testing Refractory Fire Brick," *Proc. A. S. T. M.*, **16**, 366–72 (1916).

[2] "Tentative Method of Test for Resistance of Fireclay Brick to Spalling Action," *Proc. A. S. T. M.*, **21**, 577 (1921).

[3] "U. S. Government Master Specifications for Fireclay Brick," *Bull. Amer. Ceram. Soc.*, **4**, 144–48 (1925).

are classed according to the number of quenchings they can withstand.

The quenching test used is identical with that of the American Society for Testing Materials, except that the quenching temperature is 850°C after the preheating to 1400°C. The brick is considered to have failed when the entire plane surface of the heated end has entirely spalled away. Results are reported by the number of quenchings which the brick withstood.

The Simulative Service Test

The Navy Department of the United States Government has adopted a simulative service test which is used by the Navy for selecting its fire brick.[1] In this test, two sidewalls are constructed in a test furnace, one being built of the brick to be tested, and the other being built of a standard brick. Each wall is nine rows high by three and one-half bricks long; the space between walls is four and one-half inches. The oil flame sweeps through the length of the furnace, curves upward, returns to the front, and leaves the furnace. The test is of twenty-four hours' duration and the temperature attained is 1650°C. A spalling test is conducted by blowing a blast of cold air into the furnace at the end of the test and continuing this until the brick are cool. All manufacturers whose brick pass this test are eligible to bid for the navy contracts.

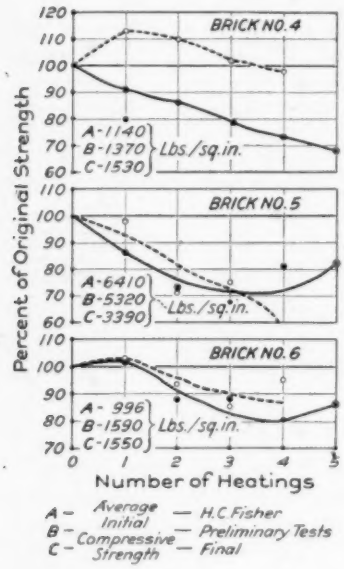

FIG. 2.

A New Method of Testing for Spalling Resistance

The individual manufacturer of fire brick is interested in obtaining actual data on the spalling resistance of his product together with comparative results which will show him whether he is raising or lowering the quality of his product. For comparison of his bricks with those of other manufacturers, he is usually satisfied with obtaining this information from a disinterested source such as the United States Bureau of Standards, the Mellon Institute of Industrial Research, or various universities. It has been

[1] H. H. Norton and R. L. Porter, "The Method of Selecting Refractories for Marine Purposes of the Navy," *Jour. Amer. Ceram. Soc.*, **7**, [7], 575–82 (1924).

shown by R. M. Howe and S. M. Phelps that a spalling test by water-quenching is satisfactory for testing any one clay but is not satisfactory for the comparison of two bricks manufactured from different clays unless the brick were reheated before testing.[1-2] It is also noted by them that the water-quenching is too severe to furnish a good comparison of some brick, and such has been the writer's experience. In developing the new method of testing, the idea advanced is that the checking and cracking of the brick caused by rapid heating and cooling would be indicated by a decrease in the compressive strength of the specimen, even though portions had not fallen off. Such a decrease, when expressed as percentage of original strength, would show numerically to what extent the brick had been injured by spalling. It is possible that time might be saved by a smaller number of heat treatments.

Description of Testing Method

The procedure given is that which the preliminary tests showed to be most satisfactory, after some data had been secured.

The brick to be tested is cut at right angles to its length, and as nearly as possible in its center. One half is placed entirely within a furnace maintained at a given temperature. It is allowed to remain there for one hour and is then removed, placed on edge, and allowed to cool in quiet air for one hour. It is then replaced in the furnace and this operation repeated until the specimen has been heated and cooled five times.

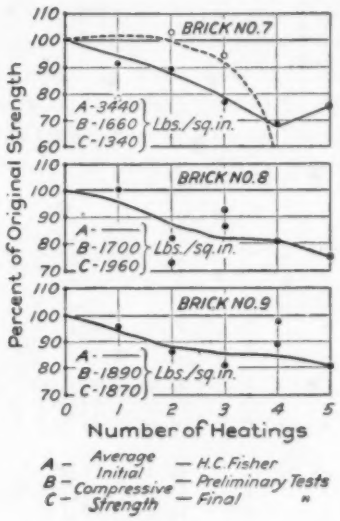

FIG. 3.

The untreated and treated halves are capped with plaster of Paris to cover any irregularities. The surface areas of the faces are measured and the average areas of the two opposite faces are recorded. The specimens are then crushed in a compression testing machine and the compressive strength in pounds per square inch is calculated. The results obtained serve as the basis of classification, and the brick having the greatest percentage of original strength left after five heat treat-

[1] R. M. Howe and R. F. Ferguson, "A Study of Spalling," *Jour. Amer. Ceram. Soc.*, **4**, 32–46 (1921).

[2] R. M. Howe and S. M. Phelps, "The Use of Plastic Clay Grog in Preventing Spalling," *Jour. Amer. Ceram. Soc.*, **4**, 119–26 (1921).

ments are considered the most resistant to spalling. If any loss in volume occurs which is due to actual spalling-off of pieces, the brick is penalized by reducing the compressive strength by the equivalent per cent obtained from the loss in weight of spalls.

In Table III, Sample No. 1 retained 68% of the original strength even though it lost 18.7% by weight. This loss is indicated by subtracting 447 pounds per square inch from 2390 pounds.

Development and Use of Test

Preliminary Tests by H. C. Fisher[1]

The testing done by H. C. Fisher was carried out by using a heating temperature of 1350°C. His work was done chiefly for the purpose of developing the test and consisted of heating the brick one, two, three, and four times each and then, after each set of treatments, determining the percentage of original strength. Curves were then drawn; these appear as dotted curves in Figs. 1, 2, and 3, and data are shown by open circles. Fisher's data are given in Table I.

TABLE I
(Preliminary tests by H. C. Fisher at temperature of 1350°C)

Brick No.	No. of heatings	End not subjected to test			End subjected to test			Per cent of orig. strength after test
		Area sq. in.	Total load lb.	Load per sq. in	Area sq. in.	Total load lb.	Load per sq. in.	
1	2	10.5	27,010	2,670	10.7	26,470	2,480	93.0
	3	10.7	36,520	3,310	10.1	34,880	3,460	105.0
	4	Failed completely						
2	1	11.0	19,530	1,790	10.0	19,320	1,930	108.0
	2	11.0	24,920	2,280	10.6	21,420	2,020	88.6
	4	11.0	12,550	1,150	11.3	13,110	1,170	102.0
3	1	11.3	11,475	1,020	11.3	11,310	1,010	98.7
	2	11.3	12,740	1,130	11.0	10,450	955	84.6
	3	11.5	10,190	885	11.3	7,825	695	78.5
	4	11.2	10,375	930	11.5	11,485	1,000	108.0
4	1	10.1	10,250	1,020	10.8	12,235	1,150	113.0
	2	11.0	13,640	1,140	11.2	14,145	1,260	110.0
	3	10.7	11,350	1,070	11.3	12,205	1,090	102.0
	4	10.7	14,285	1,340	11.3	13,430	1,310	97.8
5	1	10.7	60,000	5,640	10.4	57,510	5,530	98.1
	2	11.0	79,010	7,200	11.0	56,370	5,140	71.4
	3	11.0	69,730	6,360	11.0	52,540	4,600	75.5
	4	Failed completely						
6	1	10.7	10,760	1,010	10.6	11,030	1,040	103.0
	2	10.7	10,300	970	11.0	9,890	905	93.3
	3	10.6	11,620	1,100	10.6	9,920	934	85.0
	4	10.6	9,610	905	10.6	9,140	860	95.0
7	1	10.6	44,640	4,200	10.4	34,100	3,280	78.1
	2	10.7	32,890	3,060	10.4	33,180	3,180	103.0
	3	10.4	31,680	3,050	10.4	29,430	2,830	94.2
	4	Failed completely						

[1] Holder of U. S. Bureau of Mines Fellowship, 1923–24, Northwest Experiment Station, Seattle.

Preliminary Tests by the Writer As a preliminary study the method of Fisher was followed, using, however, the heating temperature of 1250°C. The solid curves shown in Figs. 1, 2, and 3 were then drawn, the points being located by the solid dots. The data obtained are given in Table II. From the results it was decided that five treatments would give a better classification.

TABLE II
(Preliminary tests using 1250°C)

Brick No.	No. of heatings	End not subjected to test			End subjected to test			Per cent of original strength
		Area sq. in.	Total load lb.	Load per sq. in.	Area sq. in.	Total load lbs.	Load per sq. in.	
1	1	10.5	30,400	2,880	10.8	28,750	2,670	92.8
	2*	10.7	30,980	2,885	10.7	22,420	2,100	72.7
	3	10.4	34,570	3,310	10.9	28,620	2,630	78.6
	4	10.9	43,260	3,950	10.6	28,770	2,720	68.7
	*ret	10.5	34,000	3,240	10.6	27,420	2,580	79.5
2	1	10.6	14,800	1,390	11.5	15,325	1,330	95.7
	2*	11.0	14,560	1,320	11.3	14,755	1,300	98.5
	3	10.9	12,755	1,170	10.9	11,415	1,050	89.5
	4	10.7	22,590	2,200	11.4	21,105	1,850	84.1
	*ret	9.9	10,925	1,100	11.0	11,740	1,070	97.5
3	1	11.6	20,075	1,730	11.2	18,380	1,640	94.8
	2*	11.2	26,190	2,340	9.9	19,700	1,980	84.6
	3	9.7	16,060	1,650	10.8	15,055	1,400	85.1
	4	10.4	22,465	2,150	11.0	19,680	1,790	83.0
	*ret	10.7	22,035	2,050	11.7	19,975	1,700	83.1
4	1*	10.9	15,090	1,380	10.6	11,650	1,100	80.0
	2	9.9	13,400	1,360	11.1	13,030	1,170	86.1
	3	10.6	14,480	1,360	10.7	11,490	1,070	78.8
	4	10.5	14,620	1,390	10.6	10,800	1,020	73.2
	*ret	10.2	11,415	1,120	11.4	11,485	1,010	90.1
5	1	10.8	61,500	5,680	10.6	51,650	4,880	86.2
	2	10.4	56,920	5,440	11.4	43,570	3,970	73.0
	3	11.1	57,280	5,180	8.8	30,650	3,490	67.4
	4	10.5	52,080	4,960	11.2	44,780	4,010	80.8
6	1	10.7	15,060	1,410	11.0	15,800	1,440	102.0
	2	10.6	17,840	1,690	11.3	16,880	1,490	88.3
	3	10.8	17,245	1,600	10.7	15,060	1,410	88.2
	4	10.8	18,000	1,660	11.0	14,665	1,330	80.2
7	1	10.8	17,375	1,600	11.1	16,255	1,470	91.8
	2*	10.5	17,660	1,670	11.4	17,095	1,500	90.1
	3	11.1	19,735	1,770	10.9	14,845	1,360	76.8
	4	11.0	17,785	1,610	5.8	6,375	1,100	68.7
	*ret	11.3	17,855	1,581	11.3	15,850	1,690	89.0
8	1	10.7	18,020	1,680	11.2	18,905	1,690	101.0
	2	11.2	22,175	1,970	10.8	17,520	1,620	79.1
	3	10.7	17,970	1,680	11.2	17,435	1,560	92.6
	4	10.7	19,435	1,820	11.4	17,065	1,490	81.9
9	1	11.0	21,975	1,990	10.8	20,710	1,920	96.7
	2	11.3	20,850	1,850	11.2	17,810	1,590	85.8
	3	11.3	23,110	2,040	11.1	18,365	1,650	81.3
	4*	11.3	19,080	1,690	11.1	18,345	1,650	97.5
	*ret	9.9	21,200	2,150	11.6	22,075	1,910	89.0

* means retrial

TABLE III
(Final testing using five heatings and 1250°C)

Brick No.	End not subjected to test			End subjected to test			Per cent of original strength	Per cent actual spall loss	Final per cent original strength
	Area sq. in.	Total load lbs.	Load per sq. in.	Area sq. in.	Total load lbs.	Load per sq. in.			
1	10.4	37,050	3,560	10.4	24,590	2,360	66.4		
	10.4	32,040	3,070	3.4	15,690	1,860	60.5	32.0	
	11.0	46,210	4,220	10.2	28,380	2,780	65.3	2.3	
	10.4	35,060	3,360	9.5	22,430	2,360	70.2	25.0	
	10.0	33,780	3,380	10.0	22,590	2,600	77.0	34.2	
	Aver.		3,520			2,390	68.0	18.7	55.3
2	10.6	21,800	2,060	11.4	16,350	1,440	69.8		
	9.9	22,890	2,320	11.4	19,340	1,690	72.7		
	10.5	22,070	2,100	10.7	14,620	1,370	65.4		
	11.0	16,100	1,460	10.9	14,860	1,370	65.3		
	11.2	30,240	2,730	11.1	18,100	1,630	59.7		
	Aver.		2,130			1,500	70.5		70.6
3	10.4	33,020	3,160	10.8	21,950	2,030	64.2		
	10.4	24,220	2,330	11.4	23,820	2,090	89.7		
	10.8	35,490	3,290	7.8	18,430	2,370	72.2	15.6	
	8.3	25,960	3,120	6.6	12,620	1,900	60.9	31.6	
	10.8	26,780	2,480	10.6	22,430	2,110	85.1		
	Aver.		2,880			2,100	74.4	9.4	66.1
4	10.0	13,930	1,400	9.6	10,520	1,100	78.5	28.9	
	10.9	16,720	1,540	9.6	10,400	1,090	70.8	12.1	
	11.0	17,270	1,570	9.2	10,170	1,110	70.8	2.1	
	10.9	17,620	1,620	10.3	14,180	1,380	85.3		
	10.4	15,610	1,500	9.4	11,330	1,200	80.0	31.5	
	Aver.		1,530			1,180	77.1	8.6	70.5
5	10.3	52,340	5,060	11.0	45,710	4,170	82.4		
	10.4	29,460	2,880	10.6	22,970	2,170	75.5		
	10.3	31,770	3,070	10.7	23,620	2,210	71.9		
	10.3	38,010	3,690	10.2	33,810	3,300	89.5		
	10.5	23,330	2,220	10.7	21,990	2,060	92.7		
	Aver.		3,390			2,780	82.4		82.4
6	10.9	17,320	1,590	10.5	12,890	1,230	77.5		
	11.2	19,720	1,760	9.5	14,030	1,480	84.2		
	10.6	15,630	1,480	11.0	13,200	1,200	81.1		
	10.0	15,520	1,550	10.8	15,180	1,400	90.3		
	10.8	14,680	1,360	10.4	13,480	1,300	95.6		
	Aver.		1,550			1,320	85.7		85.7
7	9.2	12,600	1,370	6.9	7,020	1,010	73.9	21.2	
	10.7	15,410	1,440	5.9	7,960	1,350	93.7	19.0	
	8.0	9,230	1,160	10.3	9,490	920	79.2		
	10.2	14,840	1,450	11.8	14,230	1,210	83.5		
	10.6	13,670	1,290	10.4	11,560	1,120	88.3	1.0	
	Aver.		1,340			1,120	83.7	8.2	76.7
8	11.3	23,750	2,110	10.6	13,780	1,300	61.8		
	11.6	26,950	2,330	11.3	21,230	1,880	80.5	18.2	
	11.0	18,510	1,680	11.4	17,500	1,530	90.8		
	11.9	25,520	2,150	11.3	20,520	1,810	84.2		
	11.4	17,150	1,510	10.4	12,600	1,210	80.1	5.5	
	Aver.		1,960			1,550	79.5	4.7	75.3
9	11.0	15,180	1,380	11.4	14,840	1,300	94.3		
	10.6	16,970	1,600	10.9	15,680	1,440	90.2		
	11.1	23,050	2,080	11.4	18,440	1,620	77.9		
	10.9	21,630	1,990	11.1	14,850	1,340	67.8		
	11.0	25,270	2,280	11.1	18,290	1,640	71.8		
	Aver.		1,870			1,470	80.3		80.3

Final Tests In order to obtain a final classification of the various brands of brick, five samples of each were chosen. These were then subjected to the adopted test, using a temperature of 1250°. The data obtained are given in Table III. The average percentage of original strength obtained from the five brick was then used to locate the last point in the curves of Figs. 1, 2, and 3.

Brick Tested The brick tested include practically all of the fireclay brick being manufactured in the Northwest, including Washington, British Columbia, and Idaho. For comparison, the writer added two commonly used brands of brick from California which had not been tested by Fisher.

Three general types of brick were studied: (*a*) the clay type represented by Nos. 1 and 5, (*b*) kaolin-quartz-mica or siliceous type represented by Nos. 3, 4, and 6. This material is residual or colluvial kaolin found in eastern Washington and northwestern Idaho, and the brick are made of run-of-bank material, and (*c*) mixtures of the siliceous types with clay or by the addition of quartz to fire clay, Nos. 2, 7, 8, and 9.

Number 2 contains a small quantity of a very low fusing clay which is mixed with the kaolin-quartz material and so more nearly resembles type (*b*), while No. 7 contains a large quantity of a soft but refractory clay. Numbers 8 and 9 are California fire clays to which some quartz has been added.

Results of Tests The dotted curves by Fisher show an increase in strength of Nos. 2, 4, and 7 which at first rise above 100% showing that the increased strength obtained from the higher temperature of 1350°C is sufficient to overcome the disintegrating effect of the thermal shock. It also indicates the value of kaolin as a clay base even when exposed to the disrupting effect of quartz volume changes. A specimen which fell below 60% after four treatments at this temperature was considered to have failed, therefore both of the clay types, Nos. 1 and 5 have failed together with No. 7 of the mixed type. The tests which were carried out at 1250°C show a slight increase in strength in only one instance, No. 6. In comparing the data obtained from the treatments at two temperatures, it is to be noted that up to two or three treatments, all of the brick have greater strength after the 1350°C test than after the 1250°C test. The decrease in strength in subsequent treatments is, however, more rapid in most cases at the higher temperatures. Numbers 3, 4, and 6 are exceptions to the last statement and all belong to the kaolin-quartz type of fire brick. They have a high percentage of their original strength left after four treatments. Number 4 shows that the higher temperature has increased the strength and produced a structure which still retains 98% of its original strength after four treatments. Number 4 probably contains the

highest kaolin content of those brick tested in this study.[1] In the interval of time between the tests made by Fisher and the later work, it is apparent that the manufacturers have improved their product, either by changing the composition or by varying the firing treatment. Numbers 1, 2, 3, 4, and 6 show an increase in strength, while Nos. 5 and 7 which originally were the highest, have now been lowered in cold, original, compressive strength.

Effect of Vitrification on Spalling

From the results obtained by Fisher at the higher temperatures it was observed that the clay type of brick represented by Nos. 1 and 5 became increasingly vitrified as the number of heatings was increased. This increase in vitrification produced a brittle body which disintegrated on the fourth treatment. The temperature of vitrification apparently is therefore the limiting temperature of good spalling resistance. Brick No. 5 has given excellent service in industrial use and has found a wide application for moderate temperatures.

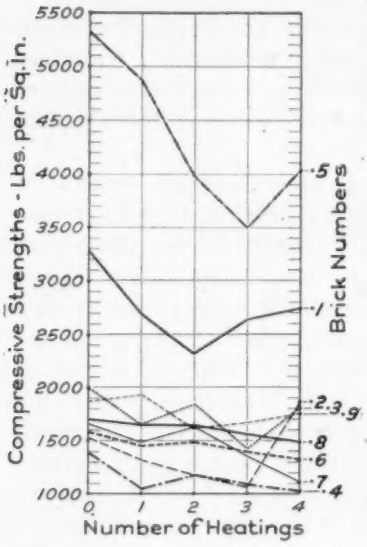

FIG. 4.

Comparison of Actual Compressive Strengths

Figure 4 shows a series of curves drawn from the data of Table II by plotting the strengths of the brick after the spalling treatment of 1250°C against the number of treatments. The irregularity of these curves illustrates the great variation in structure between brick of even the same brand. The curves clearly show the greater original strength of the clay type, Nos. 1 and 5. They also show that the clay type has far greater strength after four treatments at 1250° than any of the initial strengths of the siliceous type even after reductions are made for spalling loss in weight. This end spalling did not occur in No. 5. Great strength or hardness is advantageous in resisting the jarring stresses of moving furnaces, in resisting mechanical abrasion such as that caused in bee hive coke ovens or by the use of cleaning tools, or the handling and shipping in small lots.

In the last few years, there seems to be a tendency for the manufacturers to develop a common level of strength in their brick, for most

[1] Fire brick made entirely of pure washed kaolin have been placed on the market by one Pacific Northwest manufacturer since this study was made and these have a very high resistance to spalling.

of the stronger brick have shown decreases and the weaker ones have shown increases over a period of three years. The final average of all the brick is 2240 pounds per square inch.

Clay Type versus Siliceous Type

For some time, the siliceous types of fireclay brick have been regarded as poor resistors to thermal shock due to the rapid and large volume changes of the silica minerals with changes in temperature. This is particularly true with those clay-silica mixtures in which the clay content is the type which vitrifies at comparatively low temperatures and produces a brittle internal structure which is easily disrupted by the volume changes of the silica minerals. It does not appear to produce such a disruptive effect in the kaolin bodies studied where the clay is comparatively soft, porous, and weak at even the high temperatures and will "give and take" internally without great loss in strength from that of its original fired condition. In other words, if this theory be correct, the introduction of quartz to the clays used in Nos. 1 and 5 would be more detrimental than when mixed with the kaolins of Nos. 3 or 4. Nevertheless the strength of the kaolin brick has been undoubtedly

TABLE IV
SUMMARY OF DATA

Per cent Strength Retained after 5 Treatments at 1250°C

Number	Type	Percentage
6	b	85.7
5	a	82.4
9	c	80.3
7	c	76.7
8	c	75.3
2	c(b)	70.6
4	b	70.5
3	b	66.1
1	a	55.3

TABLE V

Compressive Strength Retained after 5 Treatments to 1250°C

Number	Type	Pounds per sq. in.
5	a	2780
1	a	1950
3	b	1900
2	c(b)	1500
8	c	1480
9	c	1470
6	b	1320
4	b	1080
7	c	1025

Those underscored lost portions of their weight by the loosening of pieces.

TABLE VI

Strength Retained after 4 Treatments to 1350°C

Number	Type	Strength lbs. per sq. in.	Per cent strength retained
4	b	1310	97.8
2	c(b)	1170	102.0
3	b	1000	108.0
6	b	860	95.0
1	a		0.0
5	a		0.0
7	c		0.0

reduced by the quartz content. This has been shown by the superior spalling resistance offered by washed kaolin brick in whose structure calcined kaolin has replaced the quartz grog.

Summary and Conclusions

(1) The method of determining the spalling resistance of fireclay brick by noting the loss in compressive strength after thermal shock very clearly shows the variation in structure between individual brick of the same brand.

(2) This method is confined to those laboratories which possess compressive strength machinery, but it possesses the additional merit of obtaining the strength of the brick.

(3) While a high quartz content in kaolin bond produces structures which have comparative low initial crushing strengths, yet this type retains a higher percentage of strength after thermal shock than the fireclay type studied in this report at the higher temperature of 1350°C, and likewise is more consistent and uniform. See Table VI.

(4) At the lower temperature, 1250°C, individual characteristics rather than type properties prevail and the results are mixed.

(5) The development of a vitrified or brittle structure appears to be the worst handicap for good resistance to spalling.

(6) A preliminary heat treatment to a high temperature eliminates many fire brick which have good resistance to spalling at low temperatures. The preliminary heat treatment to a high temperature is more of a test of the vitrification properties of the clay material and not of the article as placed on the market.

(7) If the loss in strength method were ever used for general testing of the spalling resistance, it would be well to adopt a minimum per cent loss in strength after five treatments, together with several temperatures for high, medium, and low heat duty classification, such as 1400°, 1300°, and 1200°C respectively.

(8) Five treatments at these temperatures means nearly five hours at the above temperatures and this time should be sufficient to cause the maximum degree of vitrification possible in half brick at the respective temperature.

(9) The cutting of the fire brick may lead to irregular results. This method is used, however, by the A.S.T.M. for the determination of the crushing strength of structural brick but if it is found to give irregular results, there is no serious objection to the use of ten whole brick on edge, since the crushing strength of fire brick is of a low order of magnitude. Five brick can be treated to the thermal shock and five left untreated for the determination of the original strength.

Acknowledgment

Acknowledgment is made to H. C. Fisher who carried out part of the preliminary work, to Milnor Roberts for helpful reviews, and to Hewitt Wilson of the Ceramic Engineering Department, who presented to the writer the possibilities of developing the method of testing described in this paper and revised the report.

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A STUDY OF FLUE LINING[1]

By R. A. Hart[2] and H. W. Clark[3]

ABSTRACT

Investigations conducted on various types of flue lining following the failure of several lengths in a chimney are described and data thereon are given. Standardization on a round tile lining with a minimum area of ninety-five square inches, and having a modified tongue and groove joint is recommended. The resistance to rapid temperature changes should also be improved.

Introduction

Early in 1926 a report was made to the building inspector of Salt Lake City that several lengths of flue lining had collapsed in a chimney at the home of a prominent builder of homes and that several other cases of breakage presumably due to heat had come to the attention of the builder. Pending an investigation, special permission was granted by the building inspector for the substitution of fire brick in the lower portion of chimneys, the upper portion being plastered with cement mortar.

Later it was found that advantage was being taken of this permission and orders were issued that flue lining be used. The builder objected on the ground that flue lining would not stand up but agreed to follow the ordinance until the investigation could be made. On May 18, 1926, the writers were notified that a section of 12- by 12-inch flue lining, used to increase draft in burning form lumber from a basement wall flue in a house under construction by the builder, had broken as a result of the heat.

Investigations

Inspection showed that the lining had broken into four parts first, longitudinal cracks appearing near the corners, after which transverse cracking occurred. The lining had been exposed to the air on all sides. Soot had not been burned off the inside of the lining. Two samples of the broken lining, designated A–1 and A–2 were selected for absorption tests.

Effect of Inclosing To determine the effect of inclosing, a section of flue lining was bricked in on top of the wall-section and a wood fire kindled in the wall-section. A thermometer was placed in contact with the outer surface on the lining and permitted to project through a joint in the brick work. The fire burned for twenty minutes but breakage occurred early in the experiment. There was no way of accurately determining the temperature of the gases in the flue but it was observed that the zinc melted off the surface of a galvanized tie-wire while the wire itself did not become visibly red hot. This would

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Heavy Clay Products Division.)

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indicate a temperature between 760°F and 840°F. Temperatures of the outer surface of the lining were noted as follows:

Lapse of time (min.)	Temperature °F
0	80
5	80
10	120
13	150
14	180
16	190
18	195
20	200

There was probably a differential in temperature of the inside and outside walls of the lining of 700°F at the time of the breakage.

An examination was made of conditions at the home of the builder where the original breakage had been reported. It was observed that the furnace was very close to the chimney and that the steel smoke pipe entered the flue at a sharp vertical angle. The chimney was about 35 feet in height. The boiler was a hot-water type with short flame travel. A sample of the broken lining, designated A-3 was selected for an absorption test.

FIG. 1.—Special furnaces used in tests.

On May 20, investigations were continued at the plant of the Salt Lake Pressed Brick Company, special equipment shown in Fig. 1 being built for the purpose. To compare the behavior of regular flue lining and glazed round tile under conditions comparable to those on the job above mentioned, a temporary furnace having no flue was employed. One 8- by 8-inch flue lining and one 8-inch round glazed drain tile were set up as flues without brickwork. The furnace was fired with wood, and time and temperature of flue gases, in Fahrenheit, were noted. The results were as follows:

TEST NO. 1(8- by 8-inch flue lining)

Time P.M.	Temperatures Inside °F	Outside	Remarks
2:54:00	150	air	
2:55:00	200	"	
2:56:00	330	"	
2:57:00	550	"	
2:57:15	700	"	Tile cracked
2:57:45	950	"	" broke
2:58:00	1000	"	

TEST NO. 2 (8-inch round glazed tile)

Time P.M.	Temperatures Inside °F	Outside	Remarks
3:14:00	300	air	
3:15:00	325	"	
3:16:00	410	"	
3:16:30	550	"	Tile cracked
3:16:45	630	"	" broke
3:17:30	675	"	

N. B.: Air temperature was 78°F

Another temporary furnace had been erected, in which the flue lining was bricked in and the chimney stood apart from the fire box, connec-

tion being afforded by means of a short length of pipe, thus simulating conditions of practice. The behavior of two 12- by 12-inch flue linings of one manufacture was compared with that of a 10-inch round unglazed drain tile of the same manufacture and with a 12- by 12-inch flue lining of another manufacture. The first two linings were placed in the chimney, one on top of the other. Later the top section was removed and the 10-inch round tile and the other 12- by 12-inch flue lining were substituted in turn. In the first part of the test, temperatures of the flue gases in the lower section were noted until breakage occurred, then in the upper section. Temperatures of the outer walls of both sections were taken. In the other tests, temperatures were taken only in the upper section. In the test of the round tile, breakage did not occur until after an additional section had been placed on top to increase the draft and raise the temperature. The exact temperature at which breakage occurred was not ascertained but the tile was found broken at the end of the test. Data of the tests follow:

TEST NO. 3-A

(12- by 12-inch flue lining built in brick chimney)

Time P.M.	Temperatures Inside °F	Outside top °F	Outside bottom °F	Remarks
		Bottom tile		
3:23:00	100	78	78	
3:24:00	115	78	78	
3:25:00	240	78	78	
3:26:00	320	78	78	
3:27:30	425	78	78	
3:28:00	490	78	78	Tile cracked
3:28:30	490	78	78	
3:29:00	490	80	82	
		Top tile		
3:31:00	450	82		
3:32:00	430	84		
3:33:00	475	86		
3:33:30	540	88		Cracked (?)
3:34:00	600	90		
3:34:15	650	91		Cracked
3:34:30	670	92		on top
3:35:00	705	93		
3:36:00	705	100		
3:40:00	740	116		

TEST NO. 3-B

12-by 12-inch flue lining, different manufacture)

3:57:00	235	96	
3:58:30	400	98	
3:59:00	480	99	
3:59:30	530	100	
4:00:00	590	101	Tile cracked

TEST NO. 3-C

(10-inch round unglazed drain tile)

Time P.M.	Temperatures Inside °F	Outside top °F	Remarks
4:12:00	120	90	
4:13:00	170	90	
4:14:00	260	90	
4:15:00	480	86	
4:15:30	600	87	
4:16:00	690	87	
4:16:30	725	87	
4:17:00	755	87	
4:18:00	770	88	
4:18:30	755	88	
4:20:00	730	90	
4:22:00	730	90	
4:23:30	755	99	
4:25:30	780		
4:26:00	805	108	
4:27:00	850	112	
4:28:00	890	115	
4:34:00	800	150	Tile still intact
	(Additional tile placed on top)		
4:36:00	865	158	
4:37:00	960	160	
4:38:00	1010	164	
4:39:00	1060	168	Tile found broken at end of test

The foregoing data are presented graphically in Fig. 2.

Consideration of the Data

In considering the data, it should be borne in mind that the mortar about the flue lining and tile had not hardened and was still wet, and that the temperature was raised very quickly. Such conditions should not obtain in actual

practice but they do, occasionally. They should be regarded as extreme and as indicative of what flue lining cannot stand and what it should not be called upon to stand.

In Test No. 1, it will be observed that 8- by 8-inch flue lining cracked at the end of $3\frac{1}{4}$ minutes, under a temperature of 700°F, the difference between inside and outside temperatures being 622°F.

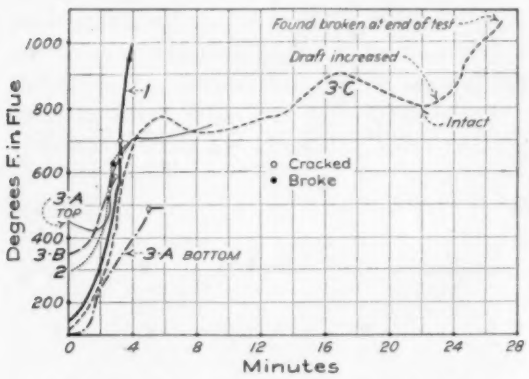

FIG. 2.—Data of tests on experimental flues.

In Test No. 2, 8-inch round glazed tile cracked at the end of $2\frac{1}{2}$ minutes, under a temperature of 550°F, the differential being 472°F. In both of these tests, the flames actually came into contact with the conduit.

In Test No. 3, the bottom 12- by 12-inch flue lining cracked at the end of 5 minutes, under a temperature of 490°F, the differential being 412°F. The top 12- by 12-inch flue lining possibly developed an incipient crack at the end of $10\frac{1}{2}$ minutes, under a temperature of 540°F, the differential being 452°F. Definite cracking occurred at the end of $11\frac{1}{4}$ minutes, under a temperature of 650°F, the differential being 559°F. The other 12- by 12-inch flue lining cracked under a temperature of 590°F, the differential being 489°F. The 10-inch round unglazed tile was still intact at the end of 22 minutes, under a temperature of 800°F, the differential being 650°F. Cracking took place at about 1000°F, the differential being nearly 850°F.

Absorption tests of samples of the several linings tested were made in the laboratory with the following results:

ABSORPTION TESTS OF FLUE LINING

Sample	Size (inches)	Thickness (inches)	Dry weight (grams)	Wet weight (grams)	Diff. (grams)	Per cent
A–1	12x12	7/8	445.97	500.01	54.04	12.1
A–2	12x12	7/8	363.10	407.64	44.54	12.2
A–3	8x12	3/4	187.65	214.40	26.75	14.2
B–1	12x12	15/16	363.15	405.24	42.09	11.6
C–1	12x12	11/16	382.15	430.55	48.40	12.7
D–1	10	7/8	377.60	432.79	55.19	14.6

NOTE: Samples A–1 and A–2 are those of flue lining broken on new job when used as a temporary flue to burn out form lumber
Sample A–3 is that from home of builder who registered the original compl int
Sample B–1 is of the first 12- by 12-inch flue lining tested in the special furnace
Sample C–1 is of the 12- by 12-inch flue lining of different manufacture tested in the special furnace
Sample D–1 is of the 10-inch round tile used as flue lining in the special furnace

The higher porosity of Sample D–1 suggests one reason for its better performance. It is believed that its shape may have had an important bearing, also. The high porosity of Sample A–3 indicates that the flue lining which failed at the home of the builder was of satisfactory quality and suggests that the failure may have been due to some special condition of installation or use.

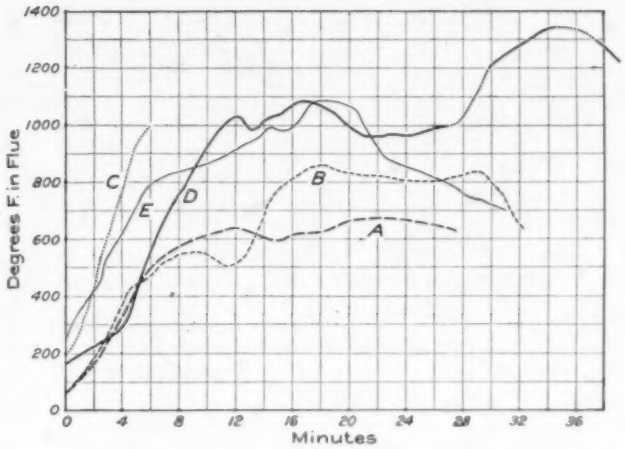

FIG. 3.—Data of tests on actual flues.

Examination of Installations

It was thought desirable to ascertain the conditions that obtain in actual practice, so an investigation was undertaken during the fall of 1926. Tests were made by the writers, of a number of installations intended to cover typical cases as indicated in the following table:

TESTS OF OPERATING FLUES

Test	Plant	Type	Diam. of fire pot (inches)	Smoke Pipe Diam. (inches)	Smoke Pipe Length (feet)	Smoke Pipe Bends (degrees)	Chimney Size (inches)	Chimney Height (feet)	Remarks
A	Warm air	Steel-Crescent radiator	19	8	11.0	1–90 2–45	8x8	30	unlined
B	Hot Water	Arco W2206	22	9	4.0	1–90	8x12	"	"
*C	Hot Water	Arco W2504	25	10	1.3½	1–30	"	"	lined
D	" "	" "	"	"	"	"	"	"	"
E	Warm air	Cast-iron circular radiator	21	8	2.5	2–45 1–90	12x12	"	"

* In this flue the lining had been broken previously and part of it had been removed

In each test, the temperature of the gas stream was measured at a point immediately adjacent to the inner surface of the flue and opposite to and one foot above the top of the smoke pipe inlet, since this seemed to be the point at which the gases impinged with the greatest velocity in their upward turn into the flue.

The same thermocouples and meter were employed as in the experimental flues. The tests were begun at the lowest chimney temperatures that could be obtained conveniently and the fires were built as nearly as possible as would be done ordinarily, no effort being made to acceler-

ate the rate of heating up. Temperatures were noted at intervals of one minute, usually, beginning with ignition. Correlative notes were

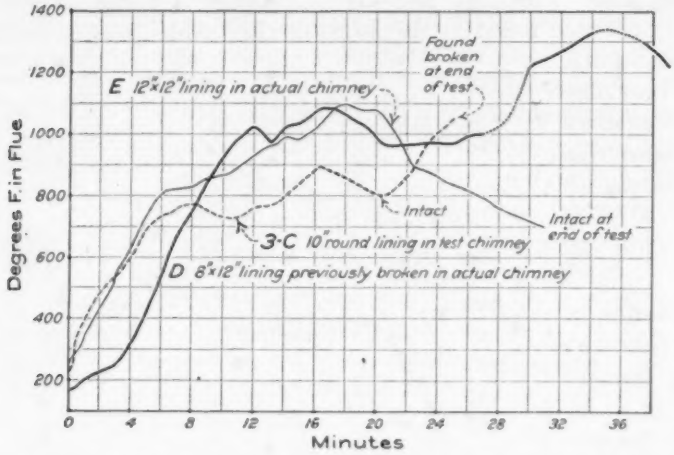
Degrees F. in Flue
Minutes
E 12"×12" lining in actual chimney
Found broken at end of test
Intact
Intact at end of test
3-C 10" round lining in test chimney
D 8"×12" lining previously broken in actual chimney

FIG. 4.—Comparison of typical curves relating to experimental and actual tests.

taken also. The results of the several tests are presented in the following tables:

TEST A. WARM AIR FURNACE
(8- by 8-inch unlined flue)

Elapsed Time (min.)	Temperature °F	Remarks	Elapsed Time (min.)	Temperature °F
0	110		16	620
1	160		17	625
2	250		18	640
3	340		19	665
4	430		20	670
5	500		21	675
6	540		22	675
7	570		23	670
8	590		24	660
9	610	Fresh fuel	25	645
10	620	added	26	630
11	630		27	550
12	610		28	
13	600		29	500
13½	590		30	650
14	600			
15	615			

TEST B. HOT WATER BOILER
(8- by 12-inch unlined flue)

Elapsed Time (min.)	Temperature °F	Remarks	Elapsed Time (min.)	Temperature °F	Remarks
0	110		16	840	
1	200		17	860	
2	280		18	840	
3	400		19	820	
4	440		20	820	
5	480		21	820	
6	530		22	820	
7	550		23	800	
8	550		24	800	
9	530		25	790	
10	510		26	815	
11	510	Fresh fuel	27	825	
12	580	added	28	840	
13	700		29	800	Draft shut
14	800		30	700	off
15	820		31	640	

Water temperature at end of test 140°

TEST C. HOT WATER BOILER
(8- by 12-inch tile lined flue)

Elapsed time (min.)	Temperature °F	Elapsed time (min.)	Temperature °F	
0	190	4	790	
1	270	5	940	
2	430	5¼	1000	(Test suspended at limit of thermocouple)
3	630			

TEST D. (SAME AS PRECEDING)

Elapsed time (min.)	Temperature °F	Remarks	Elapsed time (min.)	Temperature °F	Remarks
0	162		19	1088	
1	175		20	1062	
2	175		21	1037	
3	200		22	985	
4	225		23	962	
5	250		24	962	
6	312		25	975	
7	437		26	975	
8	564		27	975	
9	687		28	1000	
10	750		29		
11	850		30		
12	922		31		
13	985		32	1237	Secondary
14	1025		33		gas com-
15	975		34	1275	bustion in
16	1025	Waste out	35		smoke pipe
17	1037	of hole	36	1337	and chimney
18	1075	around couple			

TEST E. WARM AIR FURNACE (12- by 12-inch tile lined flue)

Elapsed time (min.)	Temperature °F	Remarks	Elapsed time (min.)	Temperature °F	Remarks
0	250		17	1075	
1	350		18	1082	
2	425		19	1075	
3	537		20	1062	Closed
4	625		21	1000	ash pit
5	725		22	900	draft
6	800		23	875	
7	812		24	850	
8	825		25		
9	850		26	812	
10	862		27	787	
11	887		28	762	
12	925		29	737	
13	937		30	712	
14	987		31	700	
15	975				
16	1000	Broke up coal			

Discussion

The plant used in Test A was chosen as typical of warm air plants which have been installed in the past, having small chimneys and rather long smoke pipes that were used to locate the furnaces near the centers of houses. In this test no unusual temperatures were obtained and there were no conditions present that would subject flue lining to undue temperatures and resulting stresses.

The hot water plant used in Test B was typical of many of the older hot water plants, where the boiler was located near the flue, even though it be on an outside wall, and a comparatively short straight connection to chimney was used. The boiler was a typical round 6 section, cast-iron boiler, having two intermediate sections between the fire-box section and the top section. No extreme temperatures were obtained.

The plant used in Tests C and D was selected primarily because the tile lining had failed during the previous winter and several sections had been removed after they had broken and fallen to the bottom of the chimney. It is also typical of the newer plants in which the low series of boilers are used in bungalows, as their draft losses are less than 5 and 6 section boilers and they may be operated on shorter chimneys. This boiler has no intermediate section between the fire-box section and the top section. The chimney temperatures encountered here were unusually high as would be expected in a boiler with practically no flame travel and very little heat absorbing surface between the fire box and the chimney.

The plant in Test E is a typical warm-air plant as it is now installed, with a chimney in a center wall of the house, and with a 12- by 12-inch

tile-lined flue. This size has been required by the Salt Lake City Building Code since April 1925. The furnace is of the ordinary cast-iron type with circular radiator, and has a shorter flame travel and a smaller heat-absorbing surface, less advantageously placed, than more expensive furnaces with other radiators. This furnace is typical of 95% of furnaces now installed in Salt Lake City. The chimney and smoke pipe conditions might be said to be representative of those in 50% of the residences, the others having longer smoke pipes which would tend to give lower flue temperatures, due to radiation from the metal pipe.

The rate at which the temperature increases is probably of more importance than the maximum temperatures obtained. The data of the tests on actual flues are presented graphically in Fig. 3. In Fig. 4 one graph from Fig. 2 and two from Fig. 3 have been plotted together to show the close relation between the temperatures and rate of temperature rise in the test chimneys, and those in actual flues. It should be borne in mind that in test chimneys the tile were either exposed to the air or were built in the chimney in which the mortar was not yet dry.

In interpreting these tests, the character of coal used in Utah should be kept in mind. It is high in volatiles, ranging from 40 to 45%. It is readily ignitable and is free burning so that new fires get under way quickly. The high volatile content results in a long flame which frequently will extend into the chimney itself. Also a secondary combustion of volatile gases may take place in the chimney, when the ash pit draft is closed and the check damper opened, with a hot fire in the boiler or furnace. This results in higher chimney temperatures and imposes much more severe conditions upon flue tile than those incident to normal operation. Such a secondary combustion occurred in Test D.

The high volatile characteristics of such fuel makes it a prolific soot producer. In heating plants with poor draft, soot may accumulate in the chimney and smoke pipe to a depth of several inches. This takes fire occasionally and burns, undoubtedly resulting in very high chimney temperatures. The writers were not able to find a plant so early in the season which had a sufficient accumulation of soot to take fire.

The burning of soot or of combustible gases in the smoke pipe and chimney can occur only with bituminous coal. Smokeless fuels, such as anthracite or coke could not produce either condition, and the duty of tile lining would not be nearly so exacting. A combination of the unusual conditions noted is undoubtedly responsible for such breakages in service as have been reported in Salt Lake City. Failures have been few, those reported representing considerably less than one-tenth of one per cent of the number in use. No breakage of tile has been reported involving 12- by 12-inch or 12-inch round tile.

Conclusions

From the data collected in the foregoing tests, and knowledge of some failures of tile, the writers have reached the following conclusions:

1. That flue linings as now made and used, while probably sufficiently rugged and durable for use with hard coal generally and for bituminous coal under normal conditions, do not afford a sufficient factor of safety for indiscriminate use in soft coal districts.

2. That the minimum flue area now permitted (75 sq. in.) is too small for best results in low, one-story buildings of the bungalow type. The smaller flues are more conducive to the collection of soot, than are the larger ones, due to their poorer draft.

3. That temperatures as high as 1300°F may be encountered, and that this temperature may be reached within 20 minutes after the fire is started with a cold chimney.

4. That a round flue lining is better able to withstand sudden temperature changes than square or rectangular flues, the rectangular falling lowest in the scale.

5. That the square butt joint of the present tile does not always result in an air-tight flue and can be improved.

Recommendations

The problem is to standardize upon a clay-tile lining that will be safe, durable, and have sufficient margin of safety to take care of any chimney temperatures that may be encountered, no matter how suddenly these temperatures may be applied, can be erected readily by the average mason to give an air-tight flue, and is of sufficient size to give ample draft, even in low one-story buildings.

After careful study of the situation the writers recommend standardization on a round tile lining, with a minimum area of ninety-five square inches for furnace chimneys and having a modified tongue and groove joint.

Such a flue lining would have an inside diameter of 11 inches and an external diameter of 13 inches, and would fit nicely in a masonry flue of standard dimensions.

The standard specifications should also include an additional clause which would determine the ability of the lining to withstand rapid changes of temperature without checking or cracking. Just what this specification should be, the writers are not prepared to say at this time. The absorption tests suggest that higher porosity would be a factor. Much additional data need to be collected on this point, but it should be within the scope of ceramists to develop a flue lining which would be satisfactory under all conditions.

DRY GRINDING CLAY TO EIGHTY-MESH[1]

By D. F. Albery

ABSTRACT

A description of two installations for grinding a terra cotta clay to 80-mesh is given. The necessity for fine grinding is explained and the difficulties encountered in development of process are enumerated. Advantages of finely ground clay and the use of air separation are described.

Necessity for Grinding to 80-Mesh

In the search for clay for the manufacture of terra cotta in the Chicago district, the clays from Colchester, McDonough County, Illinois, were investigated. These clays were found to be well suited for the purpose except for the fact that they all contained a small percentage of copper pyrite; there was not enough to render the clay unfit because of the total sulphur content, but enough, and of a grain size sufficient and so distributed as to cause a large amount of objectionable green spots on enameled terra cotta. Practically all of the other clays in Illinois, which might be considered for the manufacture of terra cotta contain sulphur, in some form, to such an extent as to render them unsuitable because of the effect of the sulphur on the glazes and enamels.

After considering the clays from Ohio, which might be used, and also the clays from Indiana, which had been the main source of supply of terra cotta clay for this district up to this time, it was decided to investigate the possibilities of refining or treating the Colchester clay in some way so as to make it satisfactory for our purposes. Consideration was given to the high freight rate on the Ohio clays and their great distance from our factories. Consideration was also given to the fast diminishing supply of clay from Indiana and also to the cost of mining this clay. The terra cotta clay from the Indiana district occurs in a vein of from 18 inches to a maximum of 24 inches in thickness, whereas the supply of clay in Colchester proved, by core drilling, to be very extensive and to occur in veins of from 5 feet to 9 feet in thickness.

Factory tests demonstrated that there were two possible methods of eliminating the trouble due to the copper pyrite present in the Colchester clay: (1) washing and screening, settling or filtering out the impurities, and (2) fine grinding and so disseminating the particles of pyrite that they are harmless.

Our investigations led to the conclusion that washing clay on such a scale as required would be considerably more expensive than fine grinding, so that it was decided to install equipment to reduce the clay to minus 80-mesh, this fineness having been proved by practical experiment to be necessary and sufficient to produce the desired results.

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Terra Cotta Division.)

Observations on the Use of Finely Ground Clay

Fine grinding of a clay to 80-mesh not only eliminates the trouble from copper spots, due to the presence of copper pyrite, but it also eliminates the specks, pop-outs, checking, etc., caused by other impurities in a clay. It increases the slaking properties of a clay, thereby enabling the production of a pressing body in which the grog, clay, and water are more intimately mixed. We have observed no practical difference in the working properties of the clay in regard to pressing, drying, tendency to warp, etc.

Description of Installations

Several types of grinding mills were considered for our first and second installations, attrition mills, high speed pulverizers, ball mills, and rod mills. The Colchester clay is a typical No. 2 fire clay, is mined underground, and as received from the mine, contains approximately 4% of moisture and is fairly soft.

The following descriptions are given of the two installations now in service: (1) Marcy Rod Mill and Clark Air Separator, at Chicago. This rod mill is 5½ feet in diameter, by 11 feet long inside. It has trunnion and double roller bearings. The mill is fed with material of about 4-inch size by means of a plunger feeder through the feed head trunnion. The capacity of the mill and the size of the mill delivery can be regulated by (*a*) length of stroke and speed of plunge feeder, (*b*) r.p.m. of mill, and (*c*) number and size of rods. An average rod charge consists of approximately 23,000 pounds, made up of 50 1½-inch rods, 67 2-inch rods, 17 2½-inch rods, and 30 3-inch rods.

With a mill speed of 17 r.p.m., and the above rod charge, a mill delivery of 18 tons per hour can be maintained. Of this 18 tons there are approximately 8 tons of minus 80-mesh clay. Following is a typical screen analysis of this product:

On	10-mesh	0.0%
"	14 "	2.0
"	20 "	10.3
"	35 "	20.7
"	65 "	17.3
"	100 "	7.8
Finer than	100	41.9

The total mill delivery is elevated and passed through a 6- by 15-foot Clark Cyclone Separator, which removes about 7½ tons of the 8 tons of minus 80-mesh clay. The tailings are returned to the mill and the fines are passed through a No. 7 Clarage Fan, which delivers 15,000 c.f.m. at 6 oz. static pressure. From the fan the fine clay is delivered into a 9 x 18-foot Cyclone Collector, from which the finished product, the minus 80-mesh clay, is delivered by gravity to storage.

The Clark Air Separator works very satisfactorily and effects a much better separation than is possible by screening. One reason for this is

that the pyrite and other heavy impurities, which are apt to cause specks or spots in the terra cotta, are dropped into the tailings due to their specific gravity. In other words, pieces of pyrite which might pass an 80-mesh screen on any screening device, are not lifted by the air in an air separator.

The Marcy Mill requires 75-horse power and the fan on the air separator system requires 43-horse power. This power was determined by a commercial testing laboratory of good standing. In twenty-eight months there have been practically no repairs on the Marcy Mill. It is necessary from time to time to add a few 3-inch rods to the mill and to remove the rods that have become too thin. In this time we have had only one broken rod in the mill. It had worn down to nearly $\frac{3}{4}$ inch diameter. The original hard iron liners are still in service in the mill. We have a set of rubber liners on hand to install in the mill when the original liners finally wear out. It was surprising to see how rapidly the fan blades would wear out with such a material as clay. A set of manganese steel blades would wear out in three or four months. We had the fan wheel coated with rubber and after a year it shows practically no signs of wear.

We encountered considerable difficulty with the cloud of fine dust that is blown through the vent on top of the cyclone collector. This is a loss in material and also creates a nuisance. We have come to the conclusion that a plain cyclone collector is not the proper equipment for this work and are planning to install a dust filter or collector for this purpose. There are several makes of dust recovery equipment on the market that recover practically all of the fine dust.

(2) Hardinge Mill and Air Classifier, at St. Louis. This Hardinge conical ball mill is known as a 6-foot by 22-inch mill. Twenty-two inches of the 7-foot length of the mill is 6 feet in diameter. From the 6-foot diameter the mill tapers to about 14-inch diameter at each end. Connected to the delivery end of the mill is a rotary classifier $4\frac{1}{2}$ feet in diameter, through which air is circulated by means of a fan of 7500 c.f.m. capacity. The fine material from the classifier is blown to a cyclone collector and the coarse material is blown back to the mill for further reduction.

The Hardinge mill requires 40-horse power and the fan 15-horse power. The mill is fed the 4-inch Colchester clay by means of a Sturtevant swinging plate feeder. The mill produces 3 tons per hour of approximately 95% minus 80-mesh clay. In twenty months service the Hardinge mill has required practically no repairs.

These two installations are producing satisfactory results at low cost and are making possible the utilization of a clay which had heretofore been considered unsuitable for the manufacture of terra cotta.

A NEW MERCURY VOLUMETER[1]

By E. S. Wheeler and A. H. Kuechler

ABSTRACT

A new mercury volumeter is presented, which has certain features not possessed by others. Principle of operation, construction, manipulation, and calibration are discussed. Its advantages and disadvantages are listed.

Introduction

In research work, particularly ceramic investigations, it is quite often necessary to make volume measurements to determine certain of the physical properties of the material. If the scope of the investigation is wide the number of such volume measurements reaches into the thousands. Unless the laboratory is excellently equipped, these measurements in themselves become a task of no small magnitude.

In the course of an investigation in the laboratories of the Missouri School of Mines and Metallurgy at Rolla, Missouri, it was necessary to make several thousand volume measurements. For the determination of volumes several types of volumeters were found to be in use; these are briefly reviewed by E. F. Goodner[2] as part of a paper describing a volumeter designed at the Northwest Experiment Station of the U. S. Bureau of Mines. No further consideration need be given to these various volumeters except to state briefly some of the disadvantages encountered in using two of the types.

Experience with Schurecht and Goodner Volumeters

Schurecht Volumeter The Schurecht overflow volumeter, which was used throughout the first part of the investigation, was discarded later, not only because of the inherent necessity for careful handling, but because of our inability to locate conveniently in the laboratory a battery of these volumeters solidly mounted.

Goodner Volumeter A mercury volumeter as described by E. F. Goodner[2] was constructed with the electrical circuit attached, as suggested by the author. With careful handling it was not always possible to obtain reliable results. It was found that the rubber tubing connecting the mercury well with the measuring burette seemed to retard the free flow of mercury. While this feature may have been due to the kind of rubber tubing used, it was found necessary to make several adjustments before being assured that the two mercury columns were at the same level. This latter fact cut down the speed with which measurements could be made, so this type of volumeter was also discarded. It may be said, however, that once the same level

[1] A contribution from the Experiment Station Laboratories of the Missouri School of Mines and Metallurgy, Rolla, Missouri. Received June 18, 1927.

[2] E. F. Goodner, "A Mercury Volumeter," *Jour. Amer. Ceram. Soc.*, **4**, 288–300 (1921).

is attained in both columns, there can be little question as to the accuracy of the results compared with results obtained with other volumeters using mercury as the measuring fluid.

New Mercury Volumeter

The type of volumeter designed for the greater portion of the investigation, and now in use in the laboratories, is described below. The volumeter has been tried out very carefully in actual work, as well as in comparative tests and in tests against a specimen of known volume calibrated by the U. S. Bureau of Standards. In each instance the volumeter has given satisfactory results. The speed with which volumes are secured leads to the belief that this apparatus has advantages over other volumeters and is worth presenting.

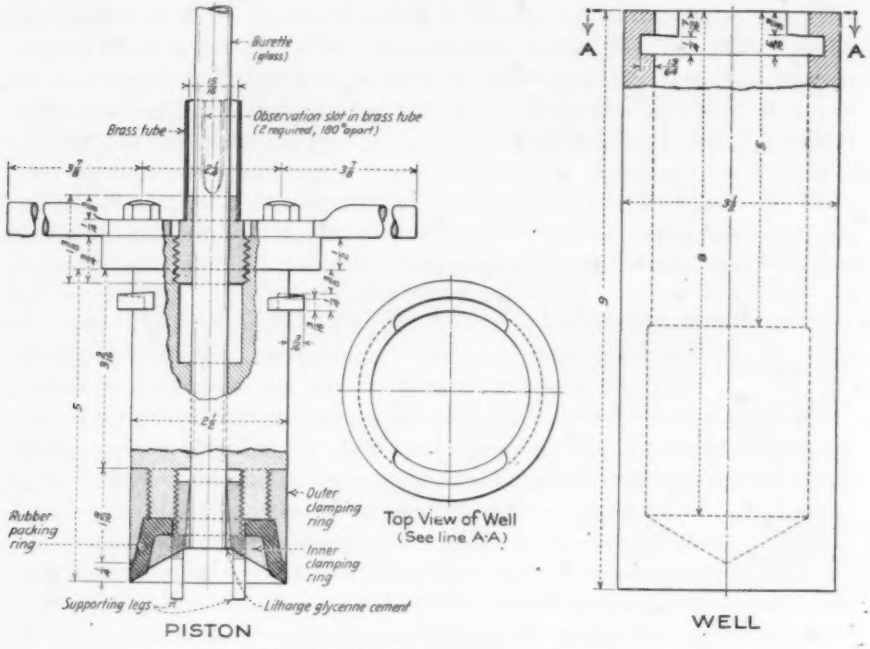

FIG. 1.—A new mercury volumeter.

Principle of Operation The principle of the new volumeter is simple. The briquet, or other object whose volume is desired, is placed in a reservoir or well containing mercury. A piston, to which a measuring burette is attached, fits into this well making a mercury tight sliding contact with the walls of the reservoir. The lowering of the piston into place submerges the briquet, forcing the displaced mercury into the burette where the volume can be read directly.

Construction As shown in Figs. 1, 2, 3, and 4 this volumeter is simple and very rugged, since there is but one glass part. It can be made easily in any well-equipped machine shop. Briefly, it consists of a steel cylindrical well, the inside walls of which are accurately machined and polished, and into which the standard sized test specimen will fit freely. A machined and polished piston fits into the well. Around the end of the piston, which enters the well, a rubber packing ring is so shaped and fastened that upon contact with the surface of the mercury the pressure of the latter holds the feather-edged rubber tightly against the smooth wall of the well, thus forming a mercury tight sliding contact.

Through the center of the piston a hole is drilled large enough to accommodate a standard burette, the stop-cock end of which has been cut off. A piece of glass tubing, approximately the same internal di-

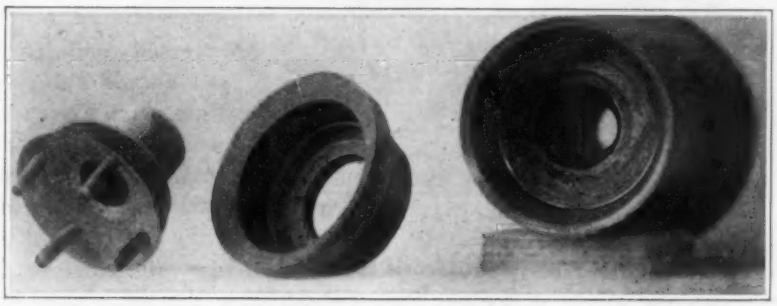

FIG. 2.—Piston unassembled.

ameter, is fused onto the end of the burette. The glass tubing should be long enough to bring the graduations on the burette within the range of vision. The burette is then inserted into the piston, and so cemented that the lower end is flush with the inner clamping ring; this prevents the trapping of air within the piston. The cement is a mixture of litharge and glycerine and is of such consistency as to be easily worked in around the glass tube. Near the top of the piston is a set of lugs which fit into grooves in the wall of the well. When the piston is given a quarter turn, these lugs force it to the same depth in the mercury on successive readings.

In order that the piston may be set on end when not in use and yet not injure the feather-edged rubber packing ring, a set of four legs are screwed into the inner clamping ring. These legs also serve the purpose of preventing the specimen from bruising the rubber when the volumeter is operated. The legs, however, tend to mar plastic specimens slightly. To eliminate this damage it is suggested that the legs be used as supports for a stirrup, in which the test pieces will fit freely. This proposed stirrup is, however, not shown in the figures.

Manipulation In operating the volumeter on specimens that are porous, the well should be filled so that the initial reading is above the first graduation on the measuring burette. Without recording an initial reading insert the specimen in the well, and push the piston to place. The mercury will settle slightly, due to the porosity of the test specimen. When the column of mercury has come to rest read the burette and remove the specimen being careful that any mercury clinging to the outside of the specimen falls back into the well. Again insert the piston and take another reading. The difference between the two readings gives the exterior volume, since any error due to mercury absorption has been eliminated by the reversed readings.

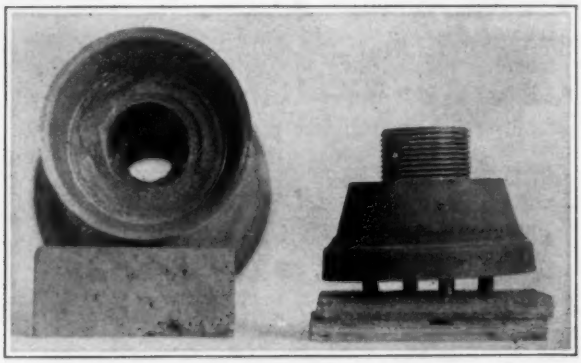

FIG. 3.—Piston partly assembled.

Should the specimens be quite porous, as is often the case with ceramic products, it is better to place them in kerosene (if dry) or in water (if fired) for a few hours before the measurements are to be made. This will decrease the loss of mercury and does not entail too great a loss of time, since on the fired specimens the volume measurements can be made directly after the saturated weight has been determined. Only on the dry specimens would an extra period of soaking be necessary.

In connection with porous specimens it is well to remember that unless given a preliminary soaking there arises the question as to what happens to the absorbed mercury when the specimen is released from under the mercury. If any appreciable amount of mercury comes out of the specimen upon being released, there will be a corresponding error in the measurements. This emphasizes the need of the preliminary soaking period to prevent the absorption of mercury to any appreciable extent.

Calibration Calibration of the volumeter is recommended as there is a slight error introduced due to the compressibility of the rubber packing ring when the latter is submerged in the mercury. This error will vary depending upon the compressibility of the rubber used. For one packing ring on the volumeter in this laboratory the correction varied from 0.07 cc in a volume of 10 cc to 0.21 cc in a volume of 40 cc. Calibration of the volumeter also corrects for inaccuracies in graduating

the burette. The calibration may be repeated from time to time as desired or whenever new rubber packing rings are placed on the piston. With ordinary handling the rubber packing ring will last an indefinite period.

To calibrate the volumeter the following procedure is used: Fill the well as given under "Manipulation" above, and record the initial reading of the burette. From a standard burette add mercury to the well in increments of approximately 10 cc, recording the amount added each time as shown by the readings of the standard burette. After each addition of mercury insert the piston and read the volumeter burette. The differences between the amounts added as shown by the volumeter and the true increments as indicated by the standard burette are the correction factors.

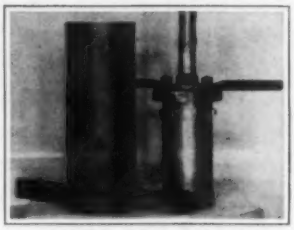

FIG. 4.—Assembled volumeter.

The Bureau of Standards calibrated a steel plummet. This was given to a number of men with instructions to make several volume measurements each. The volumes reported varied from 35.72 to 35.76 cc. The volume of the plummet as given by the Bureau of Standards is 35.78 cc.

Comparative Tests In testing out the volumeter to determine the correct procedure for porous specimens a number of comparative tests was made. The results in every instance were more consistent by far than were the results obtained from other volumeters. To determine the accuracy of the measurements of the volumeter ten steel specimens were prepared. The volume of these pieces varied from 23 to 36 cc. These pieces were measured in the volumeter by three different observers, and then the volumes were determined by the displacement method, the differences between the weights in air and in water. The notes for all tests were kept by another observer and appear in the tabulation below.

TABLE I
COMPARATIVE VOLUMES OF STEEL SPECIMENS

Test Piece Number	Volume by Displacement Method	Corrected Volumeter Measurements				Difference	Per cent error
		Observer No. 1	Observer No. 2	Observer No. 3	Average		
1	23.19	23.17	23.18	23.15	23.167	+0.023	0.10
2	36.72	36.69	36.68	36.66	36.677	+0.043	0.12
3	30.71	30.68	30.70	30.68	30.687	+0.023	0.08
4	24.16	24.14	24.14	24.17	24.150	+0.010	0.04
5	27.62	27.66	27.64	27.67	27.657	−0.037	0.13
6	29.82	29.82	29.79	29.80	29.803	+0.017	0.06
7	33.30	33.30	33.30	33.29	33.297	+0.003	0.01
8	33.67	33.69	33.67	33.69	33.683	−0.013	0.04
9	31.05	31.03	31.04	31.03	31.033	+0.017	0.05
10	32.12	32.10	32.06	32.07	32.077	+0.043	0.13

As shown in the table the difference between the average of three volumeter determinations and the volumes secured by weighing the specimens in air and water in no instance is larger than 0.05 cc. In one case there is a maximum difference of 0.06 cc between the volume as secured by one observer; all other readings vary less. The per cent error ranges from 0.01 to 0.13%. The burette on the volumeter is graduated in tenths of a cubic centimeter, and is ordinarily read to 0.05 cc. For calibration and the comparative volume tests presented in the above table estimations of tenths of a graduation or to the nearest hundredth of a cubic centimeter were made. The errors noted are more likely due to the difficulty of reading the burette correctly than to faults in the method.

Summary

A new volumeter is presented, which has certain features not possessed by others. The advantages claimed for this type of volumeter are as follows: (1) very rugged and easily constructed, (2) easily and rapidly manipulated, and (3) results are accurate for comparative work.

The disadvantages are as follows: (1) mercury is the measuring fluid, (2) soaking preferable to prevent absorption of mercury, and (3) compression of plastic test specimens.

Of the above disadvantages the last given is, perhaps, the most serious. Yet, even though there is a slight compression and sometimes deformation of plastic test pieces, it is questionable whether or not the final drying shrinkage calculation (the only one affected by the plastic measurement) is in error very much. To determine this would necessitate considerable laboratory experimentation, which the authors have not done as yet.

Acknowledgments

The writers wish to acknowledge their indebtedness to R. O. Jackson, head of the Mechanical Engineering Department of the Missouri School of Mines and Metallurgy, for his assistance in designing and constructing the volumeter; to H. M. Lawrence, Acting Superintendent of the Mississippi Valley Station of the U. S. Bureau of Mines, for his assistance and advice; and to Wm. Kahlbaum, Assistant Metallurgist of the U. S. Bureau of Mines, for his many helpful suggestions.

URANIUM OXIDE COLORS AND CRYSTALS IN LOW TEMPERATURE GLAZE COMBINATIONS[1]

By James R. Lorah

ABSTRACT

A study has been made of the color and crystallization of some uranium, lead, sodium, and boron glazes fired in a pure oxidizing atmosphere, both alone and with the addition of certain inorganic compounds. The colors obtainable are yellow, orange, red, green, brown, and black. By using only uranium oxide and red lead it is possible to produce any shade from light yellow to dark orange or red. About 10% of yellow uranium oxide is required to produce the deepest shade of orange.

A study has been made of the crystals found in these glazes and the effect on them of adding clay and certain other compounds, and of increasing the time of firing. It is shown that the volatilization of lead is a very great factor in the preparation of crystalline structures.

Introduction

The purpose of this investigation was to study the effect of certain inorganic compounds on the color and surface of low temperature glaze combinations containing uranium, and fired in an oxidizing atmosphere. These compounds were usually introduced directly into a simple raw lead glaze, but a few were prepared with a boric acid-silica frit as a base.

Uranium oxides have long been known to produce desirable color changes in glazes. In the Collected Writings of Hermann A. Seger[2] uranium oxide is mentioned as producing yellow colors. Riddle[3] studied the coloring power of uranium oxide in glazes of various compositions. Koerner[4] first noticed the tendency of lead-uranium and bismuth-uranium mixtures to form crystals. Akatsuka[5] has also obtained crystalline glazes. Wilson[6] produced good high temperature greens from certain uranium-cobalt combinations. Montgomery and Krusen[7] produced brilliant jet blacks under reducing conditions. Howe[8] produced yellow underglaze colors by the use of soluble salts of uranium. Minton,[9] Radcliffe,[10] Larkin,[11] Binns and Lyttle,[12] Akatsuka,[5] Wolfram

[1] Received April 25, 1927.

[2] Hermann A. Seger, Collected Writings.

[3] F. H. Riddle, *Trans. Amer. Ceram. Soc.*, **8**, 210 (1906).

[4] J. Koerner, *Trans. Amer. Ceram. Soc.*, **10**, 61 (1908).

[5] Mikiya Akatsuka, *Ceram. Abs.*, **2**, 142 (1923); Report of the Pottery Laboratory (Kioto), **1**, 57 (1922).

[6] Hewitt Wilson, *Jour. Amer. Ceram. Soc.*, **1**, 238 (1918).

[7] E. T. Montgomery and I. A. Krusen, *Trans. Amer. Ceram. Soc.*, **16**, 355 (1914).

[8] R. M. Howe, *Trans. Amer. Ceram. Soc.*, **16**, 487 (1914).

[9] L. H. Minton, *Trans. Amer. Ceram. Soc.*, **9**, 777 (1907).

[10] B. S. Radcliffe, *Trans. Amer. Ceram. Soc.*, **16**, 209 (1914).

[11] Paul G. Larkin, *Jour. Amer. Ceram. Soc.*, **1**, 429 (1918).

[12] C. F. Binns and F. Lyttle, *Jour. Amer. Ceram. Soc.*, **3**, 913 (1920).

and Harrison,[1] and Mathiasen[2] have produced yellow, orange, brown, and red colors. An anonymous article[3] gives a very good summary of the knowledge concerning uranium glazes up to the time of its publication.

Raw Materials

Commercial (yellow) uranium oxide, red lead, English china clay, borax, and boric acid were used in preparing the glazes. All other materials were C.P. chemicals. Since commercial oxide of uranium is a by-product from the manufacture of radium, it contains impurities of which the most important is sodium. This element is present chiefly as the diuranate and the carbonate. An analysis of the uranium oxide used in this investigation, all of which passes through a 100-mesh sieve, gave the following results: 84.4% insoluble in water, 5.4% sodium carbonate, 3.8% sodium diuranate, 6.4% moisture, 0.92% insoluble in nitric acid, and not more than a trace of vanadium.

Methods of Analysis of Uranium Oxide

Moisture was determined by drying overnight at 110°C. The portion insoluble in water was determined by treating a weighed quantity with a large volume of water, filtering through a weighed filter and drying the residue. The per cent insoluble was determined by dissolving a weighed sample in nitric acid, filtering through a Gooch crucible, and drying the crucible in the oven. The very sensitive hydrogen peroxide test was used to detect the trace of vanadium. A careful titration with standard hydrochloric acid gave the amount of carbonate present, this being figured as sodium carbonate. The soluble portion was considered made up of moisture, sodium carbonate, and sodium diuranate, and the latter was figured by difference.

Preparation of Glazes

The glaze materials were weighed out with an accuracy of 0.1%, ground wet in a small mortar, and sufficient water was added to form a thin paste. Where a frit was employed it was previously ground to 100-mesh before using. Four series of pastes were applied to biscuit wall tile and dried. Series A, C, and D were heated for one-half hour in an electric muffle furnace which was maintained at a constant temperature of cone 07 (975°C). The trials marked A. Q. (air quenched) were taken from the furnace and allowed to cool in the air. Others were allowed to cool to room temperature in the furnace, this process requiring about three hours. Series B and C22 were fired to cone 03 in a large oil-fired muffle.

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[1] H. G. Wolfram and W. N. Harrison, *Jour. Amer. Ceram. Soc.*, **7**, 857 (1924).

[2] Oscar E. Mathiasen, *Jour. Amer. Ceram. Soc.*, **7**, 499 (1924).

[3] Anonymous, *Ceram. Abs.*, **2**, 172 (1923); *Chem. Trades Jour. and Chem. Eng.*, **72**, 570 (1923).

Data

Series A

Fired to cone 07 in electric muffle. Figures represent per cent by weight

Serial No.	Uranium oxide	Red lead	Accessory compound	Description
1	none	100		Pale lemon yellow
2	15	85		Bright orange, color uneven; glassy, no crazing
3	5	85	10 CeO_2	Dirty gray olive green
4	10	70	20 "	Dirty dark green, barely fused
5	5	60	15 "	Not fused
			20 $MgCO_3$	
6	5	75	15 CeO_2	Yellow, with dark green particles floating around;
			5 Na_2CO_3	glassy, some crazing
7	5	93	2 CoO	Dull blue with tinge of green; glassy, no crazing
8	10	85	5 CuO	Deep green; glaze attacks body; rough surface
9	10	87	3 Fe_2O_3	Brown; glassy with fine crazing, color uneven
10	10	85	5 "	Dark brown, some thin portions are reddish brown which are glassy without being crazed; main portion has mat surface
11	10	85	5 $Mn(OH)_2$	Very dark brown, almost black; glassy, no crazing
12	10	80	10 TiO_2	Grayish brown, barely fused
13	10	87	3 $NiCO_3$	Orange, with light green spots floating on top; crazed glassy
14	10	80	10 SnO_2	Dirty brown, barely fused
15	10	80	10 ZnO	Bright yellowish orange; glassy with numerous bubbles
16	10	80	10 CaF_2	Orange; glassy, some crazing
17	10	80	10 $CaCO_3$	Bright orange; glassy, much crazing
18	10	85	5 $BaCO_3$	Orange, color not uniform; mat surface
19	10	80	10 "	Reddish orange, mat surface
20	15	80	5 $MgCO_3$	Orange, barely fused; mat surface with large glittering crystals on surface
21	10	80	10 "	Orange, barely fused
22	10	80	10 $Bi(OH)_2$	Bright orange with numerous very small dark spots
23	10	80	10 $CdCO_3$	Bright orange with brown flakes in spots; glassy without crazing
24	15	75	10 "	Orange; glassy without crazing
25	10	60	30 "	Light brown; glassy
26	10	80	10 K_3VO_4	Peculiar milky red; glassy, fine crazing
27	10	85	5 MoO_3	Pinkish orange; mat surface
28	10	80	10 "	Reddish brown; mat surface
29	10	80	10 $LiCO_3$	Orange tinted yellow; glassy, crazed, a few bubbles
30	30		30 K_2CO_3	Not fused
			60 SiO_2	
31	10		60 K_2CO_3	Orange, barely fused
			30 SiO_2	
32	10		20 Na_2CO_3	Yellow, barely fused
			70 SiO_2	
33	10		40 Na_2CO_3	Yellow; glassy, badly crazed
			50 SiO_2	

Series B

Fired to cone 03 in an oil-fired muffle in 8 hours. Cooled with kiln. Figures represent per cent by weight.

Serial No.	Uranium oxide	Red lead	Accessory compound	Description
1	5	95		Brownish orange; glassy, crazed
2	10	90		Same as B1 but in addition has a number of very large spots which are almost black
3	15	85		Brownish orange; mat surface
4	20	80		Brownish orange; mat surface. Crystals on surface
5	25	75		Brownish orange; mat surface. Portion not fused Surface covered with glittering crystals

SERIES B (*continued*)

Serial No.	Uranium oxide	Red lead	Accessory compound	Description
6	5	55	20 CeO_2 20 $MgCO_3$	Not fused
7	10	85	5 Fe_2O_3	Very dark reddish brown, almost black in portions. Dark portion has mat surface due to crystal formation. Reddish brown portion has glassy, noncrazed surface
8	15	80	5 TiO_2	Partially fused. Brown, color uneven
9	10	70	10 SnO_2 10 $CaCO_3$	Not fused
10	15	75	10 ZnO	Brownish orange; mat surface, glittering crystals all over surface when viewed under microscope
11	10	70	20 CaF_2	Brown, partially fused
12	10	80	10 $CaCO_3$	Brown, partially fused; surface is crystalline
13	10	75	15 $BaCO_3$	Light brown with touch of orange; only partially fused
14	15	75	10 $MgCO_3$	Not fused
15	10	80	10 $Bi(OH)_3$	Varies from light orange to dark brown; darker portions have mat surface
16	20	70	10 $Bi(OH)_3$	Deep reddish orange with some very dark portions; mat surface
17	10	85	5 $CdCO_3$	Dark orange; glassy without crazing
18	10	85	5 MoO_3	Brownish orange; mat surface, long crystals on surface
19	15	80	5 "	Orange tinted pink with large dark spots; mat surface, large crystals on surface

SERIES C

Fired to cone 07 in an electric muffle. Figures represent per cent by weight.

Serial No.	Hours of cooling	Hours in furnace	Uranium oxide	E.C.C.*	Red lead	Accessory compound	Description
1	AQ‖		10	10	75	5 Fe_2O_3	Brown with numerous darker spots; glassy but not crazed
2	3		10	15	65	10 ZnO	Brown, color uneven. Barely fused
3	3		5	15	70	10 CaF_2	Brownish orange; glassy, crazes badly
4	AQ		10	10	70	10 $BaCO_3$	Not fused
5	AQ		10	15	65	10 $Bi(OH)_3$	Orange, but covered with numerous small dark brown spots; glassy but not crazed
6	AQ		10	15	65	10 $CdCO_3$	Pale orange; dull, but not a mat surface
7	AQ		10	15	70	5 MoO_3	Brownish pink; mat surface, very rough; many glittering crystals
8	3		5	15	75	5 K_2VO_4	Light brown; portion is mat and remainder glassy, mat portion has many crystals
9	3		15	10	65	10 "	Pinkish orange; mat surface with many crystals
10	3		10	15	75		Bright orange
11	AQ		5	15	80		Light yellowish orange; glassy, no crazing
12	3		10	15	75		Orange; mat surface covered with very small crystals
13	3		15	15	70		Dark orange; dull surface
14	AQ		7	15	78		Brownish orange; crazed, glassy

* English china clay.
‖ Air Quenched.

SERIES C (*continued*)

Serial No.	Hours of cooling	Hours in furnace	Uranium oxide	E.C.C.	Red lead	Accessory compound	Description
15	AQ		12	15	73		Light brown with numerous darker spots; slightly glassy, no crazing
16	AQ		10	20	70		Dark orange, covered with light brown spots; dull surface
17	AQ		10	25	65		Dark orange, covered with brown spots; dull surface
18	3		Same as C14				Orange, covered with numerous darker spots; glassy, no crazing
19	3		Same as C15				Pinkish orange; mat surface
20	3		Same as C16				Dark orange with pinkish tinge; rough mat surface, many crystals
21	3		Same as C17				Same as C20 but has a finer grained mat surface
22			3	17	80*		Yellow; glaze very thin but has rough crystalline surface
23	AQ	1	5	25	70		Glassy, crazed
24	AQ	1	10	25	65		Dark orange covered with numerous darker spots; glassy
25	AQ	2	Same as C23				Orange with very rough mat surface, many glittering crystals
26	AQ	2	Same as C24				Dark orange with numerous darker spots; mat surface
27	AQ	3	Same as C23				Orange with very rough mat surface; glittering crystals
28	AQ	3	Same as C24				Brownish orange with very rough mat surface, large glittering crystals
29	AQ	4	Same as C23				Orange; rough mat surface with very numerous large glittering crystals
30	AQ	4	Same as C24				Reddish orange; very large glittering crystals.
31	3	4	Same as C23				Same as C25 but smaller crystals.
32	3	4	Same as C24				Dark orange; very large glittering crystals with very rough mat surface

SERIES D

Fired to cone 07 in an electric muffle. Figures represent per cent by weight.

Serial No.	Hours of cooling	Uranium oxide	E.C.C.	Frit A*	Accessory compound	Description
1	AQ	5	15		80 borax	Yellow, with greenish tinge; glassy, no crazing
2	AQ	15	25		60 "	Yellow with greenish tinge; glassy
3	AQ	25	25		50 "	Not fused
4	AQ	25	15		60 "	Yellow, with greenish tinge; barely fused
5	AQ	5	30		65 "	Yellow, with greenish tinge; glassy, crazed
6	AQ	5		95		Yellow; glassy, much crazing
7	AQ	20		80		Deep yellow; glassy, much crazing
8	3	5		75	20 $Bi(OH)_2$	Yellow; glassy, crazed
9	3	5		75	20 $CdCO_3$	Yellow; glassy, crazed
10	3	5		85	10 TiO_2	Yellow; glassy, crazed
11	3	5		85	10 MoO_3	Yellow; glassy, crazed

* Frit A was made by fritting borax and silica in the molecular ratio of 1 to 2, then grinding to 100-mesh.

Discussion

Color Effects

The general color effect produced by uranium with the following compounds may be summarized as follows:

CeO_2	dirty green colors, fusion usually incomplete
CoO	greens and blue greens
CuO	dark green
Fe_2O_3	reddish brown to very dark brown
$Mn(OH)_2$	dark brown to almost black
TiO_2	brown; fusion usually incomplete
$NiCO_3$	green spots; does not seem to disperse with main portion of glaze
SnO_2	infusible in these mixtures
ZnO	small amount acts as a flux and lightens the color
CaF_2	does not affect color; large amounts act as a refractory
$CaCO_3$, $BaCO_3$, $MgCO_3$	do not affect color; large amounts act as a refractory
Na_2CO_3, K_2CO_3, Li_2CO_3	act as fluxes and lighten colors in lead glazes. When silica but no lead is present they produce only yellow colors. Tend to produce glassy structure and bad crazing.
$Bi(OH)_2$, $CdCO_3$	intensify or may even darken orange color
MoO_3, K_3VO_4	produce pink and yellow shades

Using only uranium oxide in a lead glaze, a shade from light yellow to a deep orange or almost a red may be obtained by simply varying the quantity. Five per cent will produce a bright orange and 10% a dark orange, with a higher percentage seeming to darken the color very little. If the percentage be sufficiently increased it also acts as a refractory. The black spots in the first five of Series B are undoubtedly due to the reduction of large masses of yellow uranium oxide to the black oxide (UO_2) by some of the gases produced from the combustion of the oil used to fire the furnace. It can not be due to high temperatures alone, since all oxides of uranium are changed to the yellow form (U_3O_8) upon being heated to high temperatures in the presence of air.

Glazes containing either borax or boric acid with silica give yellow glazes with a greenish tinge and show no tendency toward the formation of any orange colors.

Crystal Formation and Mat Surfaces

Crystals under the Surface

In glazes A10 and B7 containing Fe_2O_3 millions of perfect hexagonal plates set at all angles are found, both on and below the surface. They range from 5 to 20μ in size and rotate plane polarized light.

More or less perfect hexagonal yellow plates, 10 to 20μ in size, are found in glaze A24 containing $CdCO_3$. When a large number of these are clustered together, a very small irregularly shaped spot is formed which appears darker than the remainder of the glaze.

In glaze A23 containing $CdCO_3$ numerous dark orange crystals 5 to 10μ in size are found, of the shape shown in Fig. 1*a*. They appear to have floated out from a dark reddish-brown mass while the glaze was molten. This dark mass probably consists of unfused uranium oxide.

In glaze B17 containing less $CdCO_3$ there are formed large crystals, 20 to 100μ in size, of the shape shown in Fig. 1*b*. While they are of the same general shape as those found in A23 they are much lighter in color, larger, and have a skeleton outline of a rectangle around them. This outline is only barely visible. In glaze A22 these crystals are found to have reached their most perfect form as shown by Fig. 1*c*. The center is dark reddish orange, the outer portion is light orange and clearly visible while the rectangular outline is distinct. As in the other cases, these crystals appear to have emerged from a dark mass while the glaze was still molten.

Crystals on the Surface

On the surface of the deep orange glaze C10, are numerous peculiar rough spots which consist of a large cloudy yellow mass containing what appears to be an orange-colored crystal in the center, as shown in Fig. 2*a*. This large crystal, which is about 100μ in diameter, is covered with fine feathery crystal formations arranged at right angles, as indicated in Fig. 2*a*. A detail of one of the feathery crystals is given in Fig. 2*b*. C12 has similar crystals. The entire surface of C19 is covered with the same type of crystal, only in this case they are much larger and have small crystals branching off from what once was the feathery portion of a large crystal. This is illustrated in Fig. 2*c*.

In glazes A27 and A28 containing MoO_3 the crystals have grown so large that all of the feathery edges have disappeared, leaving only an enlarged spine of the shape shown in Fig. 2*d*. The presence of K_3VO_4 also promotes the formation of large crystals which in general do not seem to have any regular shape.

In the series C23, 25, 27, 29, and 31 containing 5% uranium oxide, the first had no crystals but all the rest were covered with crystals like that illustrated in Fig. 2*d*, about 10 to 40μ in length.

In the series C24, 26, 28, 30, and 32 containing 10% uranium oxide, all except the first had similar crystals but in this case the crystals were smaller than in the corresponding glazes of the series containing less uranium oxide.

FIG. 1.

Since no tendency seems to exist for the formation of either the crystals or the dark orange shades when borax or boric acid is used in place of red lead as the principal flux in the glaze, it appears that lead oxide is essential to their production. Red lead by itself will give

only a very pale yellow color under oxidizing conditions, therefore the dark colors can not be attributed to the lead alone.

From the discussion on crystals it is evident that all of the crystals found in the above uranium glazes can be grouped in two types. The first type, which is found underneath the surface of the glaze, is illustrated in Fig. 1. These are formed only when the uranium to lead ratio has increased to a certain value. This increase may be brought about by increasing the original uranium content of the glaze, in which case crystallization starts near the unfused masses of uranium oxide. It may also be brought about by volatilization of the lead, in which case the crystallization may start any place in the glaze.

FIG. 2.

In the second type, illustrated in Fig. 2, and which may or may not be related to the first, crystallization does not start until a sufficient amount of lead has volatilized to produce a saturated solution of the solid phase (crystals) in the molten glaze. When this point is reached, crystallization proceeds. As more of the lead volatilizes the crystals increase in size. Thus all of the varied effects obtained by variations in time of heating are explained very simply..

The effect of adding certain agents such as clay, CaF_2, $CaCO_3$, $BaCO_3$, etc., which are here called refractories, is merely to decrease the amount of lead which will have to be volatilized before crystal formation starts. These materials also provide a body for the glaze and prevent local concentration of uranium oxide with its subsequent production of dark spots. Of those mentioned, clay appears to raise the fusion point of the glaze the least.

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ADSORPTION AT CRYSTAL-SOLUTION INTERFACES

II. Individual Macroscopic Potassium Alum Crystals Grown in the Presence of Gelatin and Dyes[1]

By F. G. Keenen and W. G. France

ABSTRACT

The present work is a continuation of the study of adsorption processes at solution-crystal interfaces. It consists of an investigation of the adsorption of dyes and gelatin by the various faces of potassium alum. The growth ratios of this alum were measured both in the presence and absence of the dyes and gelatin. It was found that Bismarck Brown and Diamine Sky Blue greatly affected the growth rates of the cube faces and also modified the crystal habit. This effect is explained on the basis of the ionic structure of the faces and the presence of polar groups in the dyes. The growth ratio V_{100}/V_{111} for pure potassium alum was found to be 1.61.

In a previous article on this subject[2] the growth and solution of single copper sulphate crystals in the presence of gelatin and dyes was studied. It was found that the substances changed the growth and solution velocities and also modified the crystal habit. The modification of the crystal habit and the change in growth velocities were attributed to the specific adsorption of these substances at the crystal-solution interface. To ascertain the correctness of this explanation and to obtain information concerning the mechanism of such adsorption processes the present investigation was undertaken. It consists of a study of the selective adsorption of dye molecules by the crystal faces of potassium alum and the correlation of this adsorption with the ionic structure of the faces. Potassium alum was used because its crystal structure as studied by Wyckoff,[3] Vegard and Schjelderup,[4] and Valeton,[5] indicates that its cube faces are comparable to the octahedral faces of sodium chloride in that they are populated by like ions, whereas its octahedral faces are of the "checker board" type comparable to the cube faces of sodium chloride.

Early in the nineteenth century it was found by Beudant[6] and Fourcroy and Vauquelin[7] that the presence of traces of urea caused the ordinarily cubic crystals of sodium chloride to appear as octahedra. Pasteur[8] working with ammonium bimalate, Retgers[9] with alkali

[1] Received June 20, 1927.

[2] T. S. Eckert and W. G. France, *Jour. Amer. Ceram. Soc.*, 10 [8], 579 (1927).

[3] *Z. Kryst.*, **57**, 595 (1923).

[4] *Ann. d. Physik*, **54** [4], 146 (1917).

[5] *Z. Kryst*, **56**, 434 (1921).

[6] *Ann. Mines*, 1818.

[7] *Ann. Chim.*, **32**, 130 (1808).

[8] *Compt. rend.*, **43**, 795 (1856).

[9] *Z. physik. Chem.*, **9**, 267 (1892).

halides, and Korbs[1] with sodium chloride all found that foreign materials influenced the crystal habit. Yet the action in all cases was decidedly specific and no general conclusions could be drawn.

A remarkable series of researches by Marc[2] resulted in the following conclusions. First, the action of foreign materials was due entirely to selective adsorption of these molecules by the various crystal faces, thereby altering their rates of growth. Second, a foreign material not adsorbed by a crystal did not affect its rate of growth or form. Finally, crystallization was an independent process and not the reverse of solution, as assumed by Noyes and Whitney,[3] Andrejew,[4] and Wagner.[5] This selective adsorption theory was further substantiated by Freundlich,[6] Reinders[7] and Gaubert.[8] In all these investigations the foreign material appeared entirely specific in its action.

The most recent contributions to this field have been made by Niggli,[9] Valeton[10] and Spangenberg.[11] The first of these investigators, in order to explain the relative rates of growth of crystal faces of sodium chloride, assumed zones of unsatisfied valencies in the faces of a crystal. The intensity of the zone was dependent upon the face indices. Spangenberg[11] proposed a more general theory which was experimentally substantiated by investigations of potassium alum. He suggested that those crystal faces which were populated by like ions, for example, the (111) faces of sodium chloride, had the strongest external force fields and grew most rapidly, while the faces of "checker board" arrangement, as the (100) faces of sodium chloride, had the weakest force-fields and grew most slowly.

From this one might reasonably expect that the adsorption of foreign molecules should also take place to a much greater extent at those faces populated by like ions. This idea is supported by the results reported in the earlier paper by the writers and also by the work of Marc[2] who found that those faces which adsorbed dye to the greatest extent grew most slowly.

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[1] *Z. Kryst.*, **43,** 451 (1907).

[2] *Z. physik. Chem.*, **61,** 385 (1908); **67,** 470 (1909); **68,** 104 (1910); **73,** 685 (1910); **75,** 710 (1911).

[3] *Z. physik. Chem.*, **23,** 689 (1897).

[4] *Z. Kryst.*, **43,** 39 (1907).

[5] *Z. physik. Chem.*, **71,** 401 (1910).

[6] *Z. physik. Chem.*, **75,** 245 (1911).

[7] *Z. physik. Chem.*, **77,** 677 (1911).

[8] *Compt. rend.*, **157,** 1531 (1913).

[9] *Z. für anorg. chem.*, **110,** 55 (1920).

[10] *Z. Kryst.*, **59,** 135, 335 (1923).

[11] *Z. Kryst.*, **59,** 375 (1923); **59,** 383 (1923); **61,** 189 (1925).

Apparatus and Procedure

A photographic record of the growth of the crystals was obtained with the apparatus previously described by Keenen, Bennett, and France[1] with the exception that the timing mechanism consisted of an endless tape in place of the clock.

A small seed crystal of potassium alum about 0.2 grams in weight was carefully selected as to symmetry and clearness and fastened to the end of a platinum wire by gently heating the wire and pushing it into the crystal. It was then suspended in the small glass cell and properly oriented and focused on the ground glass. The crystal was always placed with the two most prominent cube faces in a horizontal position and at the same relative position in the crystallization cell. Fifty cubic centimeters of a saturated potassium alum solution, in which had been dissolved a weighed amount of dye, was poured into the cell and the crystal allowed to grow for about twenty-four hours. The temperature was maintained at 30°C throughout and the growth was due entirely to evaporation. Pictures were taken at thirty-minute intervals, the resulting film was removed from the camera, developed, and projected on a white screen at a distance of four feet. This gave a magnification of about thirty times. Measurements were made on this enlarged image of the crystal with a meter stick and were accurate to ± 2 mm.

TABLE I

PURE ALUM

(100)	V_{100}	(111)	V_{111}
18.5	–	14.0	–
19.0	5	14.1	1
19.2	2	14.4	3
19.6	4	14.6	2
20.0	4	14.9	2
20.4	4	14.9	1
20.8	4	15.2	3
21.2	4	15.4	2
21.4	2	15.6	2
21.6	2	15.7	1
22.0	4	16.0	3
22.3	3	16.2	2
22.5	2	16.3	1
23.0	5	16.6	3
23.3	3	16.7	1
23.5	2	16.8	2
23.8	3	17.0	1
24.2	4	17.2	2
Mean	3.32		2.00

$V_{100}/V_{111} = 1.66$

The data thus obtained were recorded as in Table I, wherein (100) signifies the actual perpendicular distance between the two horizontal cube faces. V_{100} is the increase in this distance for the half-hour interval, *i.e.*, the rate of growth of the cube face. (111) and V_{111} have the same

[1] *Jour. Amer. Ceram. Soc.*, **10** [6], 435 (1927).

significance for the octahedral faces. At the bottom of the table is the ratio V_{100}/V_{111}. A complete résumé of all the ratios thus obtained is given in Table II. Any change in this number signifies that the rate of growth (*i.e.*, perpendicular displacement) of one pair of faces has been altered to a greater extent than that of the other pair. Hence this ratio affords a simple means of determining whether or not the dye has been adsorbed to a greater extent at one kind of face than another.

It was found that of the ten dyes used, only two, Bismarck Brown F and Diamine Sky Blue FF, colored the alum crystal and affected its form. Gelatin was also without effect except in such high concentrations that the solution approached the gel state.

Table I, as mentioned above is an example of the measurements made on a pure alum crystal, giving in this particular case the ratio $V_{100}/V_{111}=1.66$. The mean value of six crystals thus measured was 1.61. This ratio is much smaller than that obtained by Valeton,[1] but since he used spheres as starting points rather than crystals already in their normal polyhedral shape, the two cases may not be strictly comparable.

TABLE II

RÉSUMÉ OF TABLES I–XXII

Table	Substance	Per cent	V_{100}/V_{111}	Mean
I	Pure alum	0.0	1.50	
II	Pure alum		1.49	
III	Pure alum		1.67	
IV	Pure alum		1.80	1.61
V	Pure alum		1.58	
VI	Pure alum		1.66	
VII (*a*)	Napthole Yellow	0.01	1.56	1.62
VII (*b*)	Napthole Yellow	0.01	1.68	
VIII (*a*)	Quinolin Yellow	0.01	1.55	1.59
VIII (*b*)	Quinolin Yellow	0.01	1.63	
IX (*a*)	Methylene Blue Less than	0.01	1.69	1.66
IX (*b*)	Methylene Blue Less than	0.01	1.63	
X (*a*)	Methyl Violet Less than	0.01	1.62	
X (*b*)	Picric Acid	0.01	1.71	1.71
XII (*a*)	Bismarck Brown F	0.0012	1.27	1.24
XII (*b*)	Bismarck Brown F	0.0012	1.21	
XIII (*a*)	Bismarck Brown F	0.0025	1.10	1.14
XIII (*b*)	Bismarck Brown F	0.0025	1.15	
XIV (*a*)	Bismarck Brown F	0.0050	0.70	0.70
XIV (*b*)	Bismarck Brown F	0.0050	0.70	
XV (*a*)	Bismarck Brown	0.0100	0.64	0.63
XV (*b*)	Bismarck Brown	0.0100	0.62	
XVI	Gelatin	0.50	1.50	
XVII	Gelatin	1.00	1.57	
XVIII	Gelatin	2.00	1.24	
XIX	Diamine Sky Blue FF	.01	$V_{100}=0$	
XX	Diamine Sky Blue FF	0.005	0.28	
XXI	Diamine Sky Blue FF	0.003	1.37	
XXII	Diamine Sky Blue FF	0.001	1.14	

[1] *Loc cit.*

Table II contains a summary of all the measured ratios. It is evident that with Bismarck Brown and Diamine Sky Blue the rate of growth of the cube faces along the normal to their surfaces is retarded to a greater extent than that of the octahedral. Especially striking is the case of Diamine Sky Blue in which a concentration of .01% actually stopped the growth of the (100) faces without affecting that of the (111) faces.

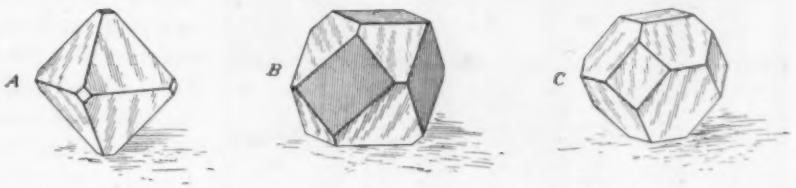


FIG. 1.

The facts noted are illustrated by Fig. 1 in which (A) is a drawing of a pure alum crystal, (B) that of one grown in .01% Diamine Sky Blue, and (C) one grown in .01% Bismarck Brown. (C) was colored light brown throughout, and it is evident that a decrease in the V_{100}/V_{111} ratio causes an increase in the areas of the (100) faces. (B) presents the startling appearance of having only the (100) faces colored deep blue, indicated by the shading on the cube faces in the drawing, while the (111) are perfectly clear. This seems without a doubt to show clearly that a dye may be selectively adsorbed by certain crystal faces, and in consequence the perpendicular rates of growth are altered thereby changing the shape of the crystal. Continued growth in this dye yields perfect cubes of alum, colored blue on all six faces.

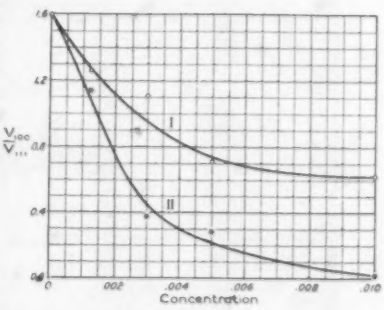
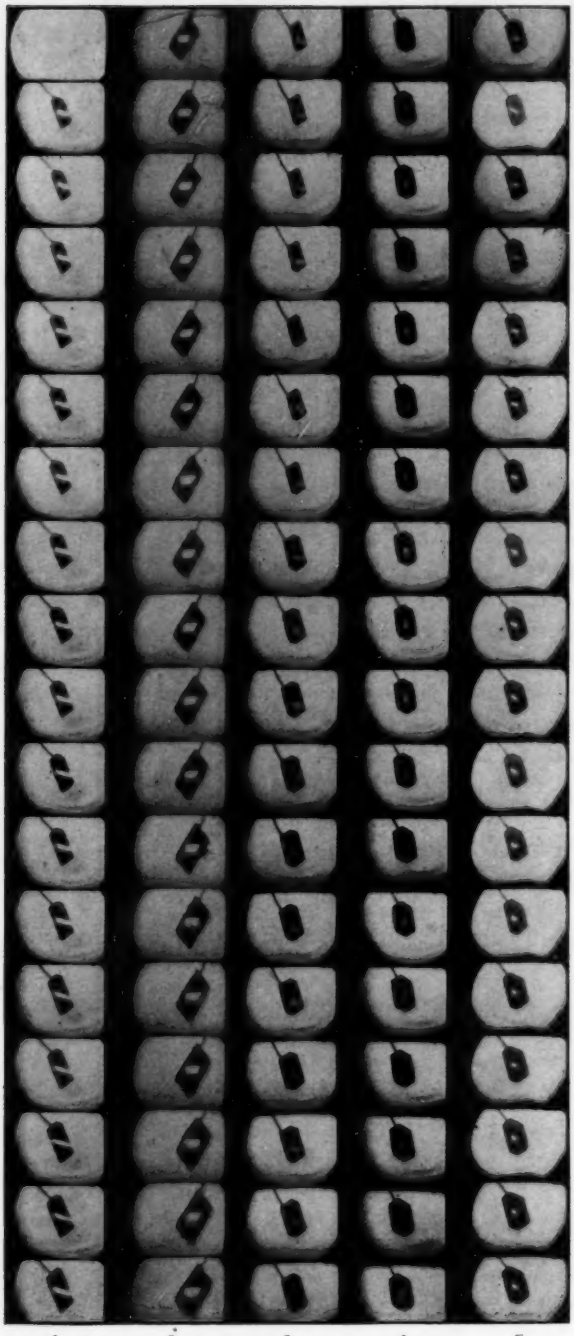


FIG. 2.

The curves, I and II for Bismarck Brown and Diamine Sky Blue, respectively, of Fig. 2 show the effect of increasing concentration of dye upon this ratio. These curves tend to flatten out at the higher concentrations. The concentrations corresponding to the beginning of the flat portions of the curves may possibly represent the adsorption of a complete monomolecular layer of dye molecules by the crystal faces[1] thus preventing further perpendicular displacement of such faces.

[1] See Paneth and Vorwerk, *Z. Phys. Chem.*, **101**, 480 (1922).



1. 2. 3. 4. 5.

FIG. 3.

Figure 3 contains actual photographs of some of the crystals measured. The cube (100) faces being the small ones in nearly horizontal position and the octahedral (111) faces, the larger ones on the sides of the crystal. No. 1 is a pure alum crystal, No. 2 is one grown in 1% gelatin, No. 3 that from .01% Bismarck Brown. The influence of increase in dye concentration is shown by No. 4, which is .001% Diamine Sky Blue, and No. 5 which is .005% of the same dye.

As has been suggested in the previous paper,[1] the observed phenomena may have their origin in one or all of three sources: the structure of the crystal face, the characteristics of the dye molecule, *i.e.*, its size, shape, existence and orientation of

[1] *Loc cit.*

polar groups, etc., and finally general environmental conditions such as interfacial energies, viscosities, etc.

The various structures assigned to potassium alum crystals by Vegard and Schjelderup,[1] Wyckoff and Valeton[1] is such that the (100) faces of potassium alum have alternating planes of Al^{+++} and K^{+} ions in one plane, and SO_4^{-} ions in the next. While the (111) faces possess a "checker board" arrangement of these ions, Spangenberg[1] used this structure to explain the more rapid growth of the octahedral faces than the cube, in accordance with his theory that faces populated by all like ions have strongest external force fields.

The results obtained in this investigation warrant the extension of this theory to the adsorption of dye molecules by potassium alum, since in each case the most pronounced effects occurred at these faces populated by like ions. That the ionic structure of the crystal face is not the only factor in the adsorption process here considered is apparent from the fact that many substances were not adsorbed at all. In this connection the presence of polar groups in the molecules and their orientation according to the theories of Langmuir and of Harkins is significant. Likewise the molecular structure, that is the position occupied by polar groups with reference to the other groups in the molecule, is of importance. It is further evident that the magnitudes of the force fields extending out from the crystal faces and from the dye molecules are also of importance. These factors together with a consideration of the effect of the interior distances within the crystal face will be considered in a later paper on ammonium alum.

Summary

(1) Bismarck Brown in concentrations of less than 0.01% decreased the rates of growth of the cube faces of potassium alum crystals to a much greater extent than those of the octahedral. Diamine Sky Blue in corresponding concentrations actually stopped the growth of the cube faces, but did not alter the rate of growth of the octahedral.

(2) The adsorption of a dye by a crystal seems to be a specific process dependent upon both the nature of the crystal and the dye.

(3) If a dye is adsorbed by a crystal it is distributed over its surface in areas of different concentrations, corresponding to the different fields of force existing at the various crystal faces. Those faces having alternating planes of like ions exhibit a much greater adsorbing power than those with a checkerboard arrangement of positive and negative ions.

(4) The ratio of rate of growth of the cube and octahedral faces of potassium alum has been found to be $V_{100}/V_{111}=1.61$.

DEPARTMENT OF CHEMISTRY
THE OHIO STATE UNIVERSITY
COLUMBUS, OHIO

[1] *Loc cit.*

American Ceramic Society

1928 ANNUAL MEETING

Ambassador Hotel, Atlantic City, N.J.

February 5-11, inclusive, 1928

National Brick Manufacturers Association Meeting Concurrently

The tentative program for meetings as agreed upon by the New Jersey Local Committee is as follows:

Sunday: Registration — President's Reception — Symphony Concert—Orchestra and Soloists—Dancing

Monday: 9:30 A.M. General Session
2:30-5:30 P.M. Division Meetings
8:30 P.M. Dinner Dance and Cabaret

Tuesday: 9:30 A.M.-12:30 P.M. Division Meetings
12:30-5:30 P.M. Division Meetings
8:30-10:00 P.M. Water Carnival

Wednesday: 9:30 A.M.-12:30 P.M. Division Meetings
2:30-5:30 P.M. General Meeting
7:30 P.M. Banquet

Thursday to Saturday, inclusive: Plant trips by Divisions in New Jersey, Pennsylvania, and Maryland.

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D. PARRY FORST, *Chairman*
R. L. CLARE
J. A. WILLIAMS
FRANK W. DINSMORE
GEO. H. BROWN
FRED A. WHITAKER

CERAMIC ABSTRACTS

Compiled by the

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[1]The abbreviation (*C.A.*) at the end of an abstract indicates that it was obtained from *Chemical Abstracts* by coöperative agreement.

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Abrasives

PATENT

Abrasives. CARBORUNDUM CO. Brit. 254,150, Sept. 25, 1925. Fused aluminous or other abrasive grains are mixed with a binder such as Albany clay and plastic ball clay and with comminuted nonvolatile organic particles such as oak wood flour which contain such a small proportion of moisture that they do not swell during heating, and the mixture is pressed into shape and fired. (*C. A.*)

Art

The native charm of Mexican hand-made tiles. MARC GOODNOW. *Arts and Dec.*, **27** [4], 42, 43, 100(1927).—The freedom and artful irregularity of Mexican hand-made tiles seem to indicate an easy flowing process, but in truth they represent toilsome devotion over 10 or 12 weeks. The Mexican Indian continues the art learned from the Spaniard who was taught by the Moor. The clay stands for days in a watery solution to settle its impurities, then is allowed to stand while the water drains off or evaporates, a sweetening process. Then for 2 weeks the doughy clay is kneaded by hand and tramped by foot to work out any remaining sand or grit that might cause an imperfection. The molding is done into a rectangular form made from a heavy root. In curing, each tile is stood upon edge and turned every day for 4 or 6 weeks. The painting of the decoration is entirely free hand, the artists often beginning at the age of 3 and becoming expert at 12. The colors attain bold rich contrasts but delicate shades are also used. In many architectural details, these tiles afford distinction in color and pattern but must be properly placed lest they "speak without being spoken to." E.B.H.

Hildreth Meiere, Mural Painter. ANNE LEE. *Arch. Rec.*, **62** [2], 103–12(1927).—H. M. is a pioneer in decorative work because her designs represent the first attempt to use tile structurally. The pattern is indicated entirely by the shape of the tiles, each in a plain color, glazed, and pieced together with painting-on reduced to a minimum. The execution of the tiles is an all-hand process. When the tiles have been made the design is assembled at the factory like a jig-saw puzzle and sent to the job in large blocks. The tiles are used on a much larger scale than has previously been attempted. Her other innovation in architectural decoration is the use of gesso on a back ground of acoustic tiles. The plaster is applied in relief, hot, and by hand, then gilded and painted. E.B.H.

Crolius and early American stoneware. MALCOLM VAUGHAN. *International Studio*, **87** [363], 56–60(1927).—Extending over 4 generations, the Crolius pottery,

sturdy and peasantlike, has long been honored as the earliest stone ware made in the American colonies. It is simple in shape, often single in color. The purpose was to produce practical and durable utensils, but though the makers never seemed to try for beauty, Crolius ware displays good taste in all its elements, shape, color, and decoration. Very probably there was a Crolius Pottery as early as 1729 but no examples of that period have been authenticated. Several examples of Crolius are illustrated, the surface colors being light blue, gray, or brown, with ingenuous figures of dark blue or dark brown painted on with a full brush or incised and carefully painted, and the whole salt glazed. As early as the middle of the 17th century one or more potters were busy in New Amsterdam but their work is unidentified. Much of the early pottery is rather crude. E.B.H.

Korean ceramics. H. G. HENDERSON. *Bull. Met. Mus. Art*, June, pp. 172–75, 1927.—The Korai period lasted from 918 to 1392 and art flourished in Korea during this time as proved by excavations of the graves around Song-do, the principal city of the Korai kings. At the fall of the Korai dynasty a new capital was established at Seoul and the old capital was deserted. Thus the Song-do graves can all be dated to the Korai period. They contain many fine ceramic pieces, some typically Korean, others so like Chinese Sung wares that some authorities have believed them Chinese importations. The Museum has recently purchased from the estate of the late Desmond FitzGerald some 20 important pieces of Korai ware which thoroughly round out the Museum collection. They are now in Gallery D 1. The most typically Korean method of ornamenting pottery consisted of inlaying black and white clay on a grayish body and then covering the piece with a transparent glaze, usually a greenish-gray. The Japanese who imitated this extensively called it "mishima" because one of the favorite patterns resembled rows of ideographs as printed in the almanacs compiled at Mishima. Several new examples of this type have been acquired. The most beautiful piece the Museum owns in the whole Korean collection is a large oval vase, slightly modeled in relief, and covered by a thick glaze of semitransparent gray-green celadon. During the 12th century a Chinese writer visited Korea and reported that they made fine pottery and porcelain there, much of it like various celebrated Chinese wares, including the highly prized Ting yao and Ju yao. The new accessions include both these types. After the overthrow of the Korai dynasty in 1392 the name of the kingdom was changed to Chosen. The dynasty then founded lasted from 1392 to 1910 and this is referred to as that of Chosen or Richo. The Richo period was a time of artistic decadence—the best ceramic pieces we know are porcelains decorated under the glaze with blue and red. The Museum has also acquired a large Richo jar with finely contrasting underglaze colors. The workmanship is much like that of certain Ming porcelains made in southern China. A.A.A.

A princely gift of Renaissance maiolica. C. LOUISE AVERY. *Bull. Met. Mus. Art*, June pp. 161–68, 1927; reprinted in *Ceram. Age*, **10** [1], 16–20 (1927).—For many years the Metropolitan Museum has been able to make a splendid showing of Renaissance maiolica, composed of pieces owned by the Museum and of loans from generous owners. In 1907, V. Everit Macy loaned 20 handsome pieces, and since then, 20 more. Recently Mr. Macy gave these 40 pieces to the Museum in memory of his wife. The secrets of metallic lusters were carried to Spain by Arab and Moorish potters. Spain being rich in deposits of tin, tin-enameled pottery was produced in quantities especially in Malaga and Valencia, the designs showing Oriental influence. Much of this ware was imported into Italy in the Middle Ages, in ships that called at Maiorca, thus giving the impression that it was Maiorca ware or by a slight change Maiolica. Originally applied to luster-ware the term was extended to include all the tin-enameled pottery of Italy. The earliest period of the richly decorated Maiolica covers the second half of the 15th century when Faenza was the chief center of production. The ornament was

bold in motives and colors. Caffagiolo, Castel Durante, and Siena came into prominence and the ornament became more pictorial. Finally, instead of using original designs the potters used adaptations of designs made for other things. The art further degenerated in the 2nd half of the 16th century, the white ground being spotted with tiny grotesques and with medallions inclosing scenes or figure subjects, a style inspired by Raphael's paintings in the Vatican. The rest of the article describes in detail the individual pieces of the collection, which illustrate the different phases of development of Renaissance Maiolica. The earliest piece in the collection was probably made in Florence. A single plate illustrates the work of Sienese potters. A group illustrates the wares of Faenza and Caffagiolo and there are very fine Faventine pieces. There are very fine examples of Deruta and Gubbio wares. The whole collection is comprehensive and of very high quality. A.A.A.

The place of ceramics in the artistic life of today. EDWIN REDSLOB. *Tonind. Ztg.*, **51** [29], 479–82 (1927). F.P.H.

English porcelain: Wallace Elliot's collection of Bow and Lowestoft. B. RACKHAM. *The Connoisseur*, June, 1927.—Eight illustrations and two full-page plates in color. H.H.S.

Greek pottery finds. *Morning Post*, June 29, 1927.—The excavations of the British School of Archaeology at Boubousta have unearthed masses of hand-made pottery, decorated in bold geometric designs, belonging to the Mycenean age. H.H.S.

Ceramic museum at Naples. *Morning Post*, June 30, 1927.—The Villa Floridiana now houses one of the finest collections of porcelain in the world, that of the Duke of Martina, bequeathed to the City of Naples. There are 10,000 pieces in the collection, occupying 21 rooms, and including work from Faenza, Urbino, Saxony, Amsterdam, Vienna, Zurich, porcelains from China and Japan, Murano glassware, Renaissance majolica, and Van Dyck enameled caskets. H.H.S.

Cement, Lime, and Plaster

Revised specification for Portland cement. ANON. Bur. Stand., *Tech. News Bull.*, No. 123, p. 6 (1927).—Changes made in 28-day tensile strengths from 200 and 300 to 225 and 325 lbs./in^2; the specific gravity test has been eliminated and other minor miscellaneous changes made. R.A.H.

A new acoustical plaster. ANON. Bur. Stand., *Tech. News Bull.*, No. 123, p. 6 (1927).—By adding small amounts of alum or aluminum sulphate and a carbonate to a calcined gypsum-sand dry mix it has been found that a plaster may be prepared which possesses the desired characteristics of surface porosity necessary in a satisfactory acoustical plaster. An investigation on this subject is now in progress at the Bureau of Standards. R.A.H.

Cement-lined water mains. HARRY Y. CARSON. *Ind. Eng. Chem.*, **19** [7], 781–83 (1927).—C. considers the factors in municipal water supplies which contribute to "red water" troubles and discusses the value of a cement lining for preventing tuberculation and internal corrosion of iron pipes. Examples of the great durability of some early cement linings as invented and put into use a half century ago in New England are given. The calcium hydroxide of the fresh cement lining is capable of raising the initial water that enters the cement to a high p_H value. There follows a diffusion of calcium to the water and a constant lowering of the alkalinity of the cement until final equilibrium is established. The cement is not easily flaked off by the rust. R.J.P.

Preparation of mosaic slabs. ANON. *Master Builder* (776), 63–64 (1927); *Tonind. Ztg.*, **51** [25], 415 (1927). F.P.H.

X-ray study of limestone calcination. FRIEDERICK RINNE. *Rock Prod.*, **30** [15], 61–63 (1927).—The 2nd of a series of articles on this subject. Photographs of X-ray

spectra of burned lime, dolomite, and burned dolomite are given. X-ray diagrams showing the changes taking place in firing clay are given. For Part I see *Ceram. Abs.*, **6** [9], 370 (1927). F.P.H.

Economy of waste heat installations in the cement industry. OTTO SCHOTT. *Rock Prod.*, **30** [15], 66–67 (1927). F.P.H.

Burning of lime in tunnel kiln. WALTER POHL. *Rock Prod.*, **30** [15], 68–70 (1927). —A report of large scale tests carried out in Germany. The advantage and disadvantages of tunnel kilns for this purpose are given. A sectional view of a German ceramic kiln used in burning lime is given. It is concluded from these experiments that for medium and large scale production the tunnel kiln can be operated economically for burning lime. F.P.H.

Requirements of metallurgical limestone. OLIVER BOWLES. *Rock Prod.*, **30** [15], 82–85 (1927).—The 2nd of a series of articles deals with (1) production problems, (2) consideration of impurities, and (3) production cost of fluxing stone. For Part I see *Ceram. Abs.*, **6** [9], 370 (1927). F.P.H.

Recarbonization, cause of contamination of lime in kilns and other studies. VICTOR J. AZBE. *Rock Prod.*, **30** [16], 54–56 (1927).—A. states that the carbon dioxide is easily reabsorbed under certain conditions. Magnesium oxide does not act in a similar way. A method of making magnesium oxide from dolomite is suggested. F.P.H.

Cement made from limestone, fullers' earth, and kaolin. ANON. *Rock Prod.*, **30** [16], 57–64 (1927).—A description of Plant No. 2 of the Penn-Dixie Portland Cement Co. F.P.H.

Chemical Lime Company's new hydrating plant. GEORGE M. EARNSHAW. *Rock Prod.*, **30** [16], 74–75 (1927).—A description of plant of the Chemical Lime Co. F.P.H.

The automatic shaft kiln in the lime industry. THEODORE KLEHE. *Tonind. Ztg.*, **51** [10], 137 (1927). F.P.H.

Machinery for the lime works. HORST LAEGER. *Tonind. Ztg.*, **51** [10], 143–44 (1927).—A short description of machinery for grinding transporting, storing, and separating lime. F.P.H.

Magnesia cement and colloidal silica. H. LUFTSCHITZ. *Tonind. Ztg.*, **51** [14], 207–208 (1927).—L. concludes that silica has a highly beneficial effect on magnesia products, resulting from the calcination of magnesium carbonates. He thinks it possible to obtain magnesium cements of greater strength and durability than either Portland or alumina cements. F.P.H.

X-ray study of the calcination process. ANON. *Tonind. Ztg.*, **51** [14], 209 (1927); *Rock Prod.*, **30** [6], 82 (1927).—Studies of this subject were made by M. V. Laue, W. H. Bragg, W. L. Bragg, Debye, and Scherer, Schibold, etc. Debye and Scherer developed a process for the examination of dense or earthen materials. The X-rays reveal the molecule structure of crystalline substances, showing the arrangement of atoms with great accuracy.. Chemical reaction can thus be studied, such as a loss of water or carbon dioxide and as decompositions into a solid residue and volatile compounds. These reactions make up the calcination process. Gypsum is formed by partially driving off the water of the gypsum rock; lime is formed by the elimination of carbon dioxide; similar processes take place in the calcination of clay and cement. X-rays yield accurate analysis of all intermediate stages, as well as of the raw material and of the finished product. It was thus found that no change of form takes place during calcination of lime, which is entirely a chemical reaction. Burning proceeds gradually, spreading over the surface somewhat like an etching process. In burning dolomite, the two constituents react independently, CaO being formed next to the MgO. It is clear that a precise knowledge of changes of structures involved is of tremendous scientific importance. F.P.H.

Colloidal silica: its utilization in cements and cement mortars. H. HINZE. *Tonind. Ztg.*, **51** [15], 223–25 (1927).—Researches by Le Chatelier and Hauenschild leave us in doubt that the increased activity of cement in the presence of soluble silica is due to the formation of an initially colloidal lime hydrosilicate. The transition period from a colloidal to a solid stage is marked by a temporary drop in strength as confirmed by numerous tests. This drop noticeable at 7 days, is entirely obliterated after 28 days water curing, when the strength values of cement with admixtures of soluble silica are considerable higher than those of ordinary cement. F.P.H.

The work of the Kiln Committee of the German Portland Cement Association. ANON. *Tonind. Ztg.*, **51** [15], 231 (1927). F.P.H.

Effect of colloidal silica on lime and lime hydrate. H. LUFTSCHITZ. *Tonind. Ztg.*, **51** [17], 259–62 (1927); *Rock Prod.*, **30** [9], 76 (1927).—Tests were made by L. in 1919 at the Dresden laboratory on the effect of colloidal silica on hydrated lime and quicklime. The results were compared with those of standard lime mortars. The colloidal silica used was in the form of a loose, yellowish powder containing about 60% silica and some moisture. Test specimens of the following compositions were made: lime and sand (1:3 mortar), lime with a large proportion of colloidal silica+sand (1:3 mortar) and lime with a little colloidal silica and added sand to make a 1:3 mortar. These were broken at the end of 7 and 28 days air and water storage to determine the tensile and compressive strengths. The best strengths were obtained with mortars of dolomitic lime and colloidal silica in the proportions of one to one-half (by weight) respectively. The results proved that colloidal silica had a beneficial effect on the strength of lime mortar; that this effect was particularly pronounced in the case of burned and pulverized lime; that hydrated lime and Portland cement showed opposite effects of silica. The conclusion was drawn that the quantity of free lime present in the cementing material was of importance and that calcined and pulverized products lying within the range of hydrated lime and Portland cement were especially benefited. The increase in strength of lime mortar due to colloidal silica admixtures is caused by the formation of lime-hydrosilicate. The more favorable effect on quicklime is explained by greater activity of this form in contact with water and by its fineness favoring maximum development of colloid chemical activity. F.P.H.

Testing small cement specimens. U. TOCHTERMAN. *Tonind. Ztg.*, **51** [17], 305–306 (1927). F.P.H.

Constituent proportions of magnesia cements, their soundness and tensile strength. KEPPELER AND MÜLLER. *Tonind. Ztg.*, **51** [25], 395–98 (1927). F.P.H.

Coloring materials for cement products. B. BREUNER. *Tonind. Ztg.*, **51** [30], 499–502 (1927).—The requirements for all colors are discussed. The types of coloring materials for this purpose are described. F.P.H.

Colloidal silica. H. LUFTSCHITZ. *Tonind. Ztg.*, **51** [32], 544–45 (1927); *Rock Prod.*, **30** [14], 96 (1927).—L. discusses arguments by Dr. Natho (*Rock Prod.*, **30** [9], 76 (1927)) on colloidal silica. N's. fundamental idea is that a numerical ratio should be established between lime and silica, whenever lime or cement are combined with silica, so that "the total CaO present is transformed by the silica to a trisilicate in the case of lime and to a 2½-silicate in the case of cement." A contradictory statement is noted: "that not only the soluble silica, but also the insoluble, quartzitic silica is effective." The latter, however, can hardly be placed into a chemically numerical relation with lime, as expressed by N. by the ratios of $3.0CaO \cdot 1SiO_2$ or $2.5CaO \cdot 1SiO_2$. As an example, N. quotes the case of the hydrochloric acid extract of brick dust which produces increased strength. Though this is correctly interpreted by N. it should be ascribed to the fact that surface changes of an admixture become apparent particularly in the tensile strength of mortar. That silica can be effective when extracted with hydrochloric

acid may be proved by a test, in which dolomitic lime was mixed with extracted silica (one-quarter of the quantity of lime) and yielded a compressive strength at 28 days of a 1:3 mortar of 113.8 kg./cm. (1615 lb./in.) while trass treated in the same manner mixed with the lime yielded but 54.4 kg./cm. (772 lb./in.). Though no numerical relations have as yet been worked out for the proportions of silica and lime, L. has obtained best results with a monocompound of the free lime and soluble silica. It is to be noted that an increase in soluble silica is observed wherever an etching substance is present in contact with water, more especially in the presence of heat or even pressure, as in the manufacture of sand-lime brick, the energy being increased. This increase of silica in the steam boiler and the relation of lime to the new quantity of silica form the subject of extensive tests conducted by L., whose results will be published in the near future. F.P.H.

High-test Belgian Portland cement. ANON. *Tonind. Ztg.*, **51** [35], 624 (1927); *Rock Prod.*, **30** [13], 84 (1927).—The production of high-test Portland cement has been reëstablished in Belgium, the product being designated by the trade name "Ceberit." The tensile and compressive strength of a 1:3 mix with sand not specified appears to be: at 1 day, 24.7 and 268 kg. per sq. cm. (350 and 3800 lb. per sq. in.) respectively; at 3 days, 36.3 and 419 kg. per sq. cm. (515 and 5950 lb. per sq. in.); at 7 days, 42.0 and 671 kg. per sq. cm. (600 and 9520 lb. per sq. in.); at 28 days, 51.3 and 693 kg. per sq. cm. (730 and 9900 lb. per sq. in.). The method of curing is not indicated, although the values of strength of Portland cement quoted for comparison are as follows: at 28 days, 31 kg. per sq. cm. and 430 kg. per sq. cm. (440 and 6100 lb. per sq. in.) respectively. F.P.H.

Effect of calcination temperature on rate of solution of lime. ANON. *Tonind. Ztg.*, **51** [42], 739 (1927); *Rock Prod.*, **30** [13], 84 (1927):—P. Budnikoff studied the rate of solution of lime calcined at different temperatures and the effect of certain admixtures on the rate of solution. The method used was based on determinations of electric conductivity. The material used was a calcium oxalate by Kahlbaum calcined in an electric furnace at temperatures of 600, 700, 800, 930, 1000, 1200, 1400, 1700°C during a period of 2 hours. An oxyacetylene flame and an electric arc furnace were also used. The time was reduced to ½ hour in the latter tests. The determination of electric conductivity was made in a 300 cc glass container at 20°C. The container was provided with a thermometer and an electrically driven agitator. Conductivity was measured under thorough agitation of the mass (3000 r.p.m.). The container was tightly sealed to eliminate the effect of CO_2. Electric conductivity depends on the quantities of Ca and OH ions. The higher the conductivity the more thorough is the hydration and consequently, the solution of lime. Therefore, conductivity is an indication of the rate of solution. The curves showed a maximum rate of solution for a lime calcined at 1100°C, the maximum of conductivity being reached in 5 min. The rate of solution of lime calcined at 800°C corresponded to 9 min.; 930°C to 8 min.; 1200°C to 9 min. and 1400°C to 15 min. The solution process was very slow for lime calcined at 1700°C in an electric arc. Further tests were made to determine the rate of solution of natural lime calcined at the same temperatures as the chemically pure lime of the first series of tests. The values showed that the conductivity of a calcined natural lime is lower than of chemically pure lime. Maximum rate of solution took place in 12 min. with a lime calcined at 1100°C. The rate of solution of regenerated (repeatedly hydrated and calcined lime) lime was also determined. The results showed little effect of repeated burning on the rate of solution. Silica was added to calcium oxalate in amounts of 2.5, 10, and 20%, and its effect was studied. The mixture was calcined at 1100°C for a period of 2 hours. The tests showed a decrease of conductivity for high percentages of silica admixtures. The following conclusions were drawn: (1) the maximum rate

of solution takes place with a lime calcined at 1100°C; (2) increased temperature reduced the rate of solution, though inappreciably; (3) the rate of solution of regenerated lime calcined at 1100°C is somewhat lower than that of lime, calcined at the same temperature; and (4) the composition of the material used has a marked effect on the rate of solution. Thus, a lime, which is the product of a limestone containing admixtures of SiO_2, MgO, Al_2O_3, Fe_2O_3, etc., dissolves more slowly than a chemically pure lime, calcined at the same temperatures. Further tests should determine the possible colloidal state of $Ca(OH)_2$ in the solution of CaO calcined at different temperatures. These tests are made by means of the Ostwald viscosimeter with a simultaneous determination of conductivity. The rate of solution of MgO is determined in the same manner. F.P.H.

Watertight cement roofing tile. ANON. *Tonind. Ztg.*, **51** [42], 745–47 (1927). F.P.H.

Strength variations of Portland cement lime mixes. H. LUFTSCHITZ. *Zement* (19) 377–79, (20) 401–403 (1927); *Rock Prod.*, **30** [14], 96–97 (1927).—L. points out that admixtures of silica and alumina to calcium oxide result in increasingly high quality of the product. Instead of elements, we deal here with oxides. Porcelain, endowed with high tensile strength combined with low expansion, represents an ideal among non-metallic substances. The development of the Portland cement from lime, its forerunner, shows clearly a constant increase in the silica content. Even the Romans had an established practice of adding trass and other similar substances to lime. In recent years, the search for a high strength cement has resulted in a further increase of the silica content, which was found to have a favorable effect on tensile strength and soundness. Soliditite, a high strength cement, is obtained by the addition of heated quartz (sand) to ordinary Portland cement. It is probable that the heating process and the resulting physical changes of the quartz benefit the tensile strength as well as the increased silica. Silica may be added before or after calcination. American Portland cement has a higher percentage of silica in the raw mix than the German Portland cements. Siliceous substances, which may be added to cement, form a large group. L. made parallel studies of their effect on Portland cement and lime. Increased strength of Portland cement due to such admixtures may be expected only when free lime is present in corresponding proportions. This beneficial chemical action is noted especially in underburned cements. It is frequently the case that admixtures are called upon not to increase the quality, but to keep certain cements suitable for definite purposes. L. succeeded in raising both tensile and compressive strength of cement, by adding moist colloidal silica to red hot cement clinker. The tensile strength was raised from 17 (without silica) to 27 kg. per sq. cm. in a few days (from 241 to 383 lb./in.). A 50% admixture of lignite ash, a material very similar to natural trass, resulted in reducing the quality of cement to that of ordinary cement. Thurament, a slag, results in a rise of strength of cement, due to the fineness and the silica content of this material. Rine trass, Bavarian trass, and Cemolite are natural products of volcanic action. Colloidal silica is a by-product of alum manufacture and is formed during the decomposition of clay by sulphuric acid. The beneficial action of colloidal silica on lime was studied by using the same admixtures. In certain cases the quality was improved to equal the standards of slag cements, known as standard cements. An outstanding instance was that of a dolomitic lime which had no strength under water and which was raised to 206 kg. per sq. cm. (2923 lb./in.) in a 1:3 mix. The effect of lime admixtures to Portland cement was next studied. Portland cement was mixed with 1, 2, and 3 parts by volume of lime. A reduction of quality was noted, particularly apparent in the case of hand-mixed specimens. Aside from the physical and chemical action involved in the manufacture and use of Portland cement and lime, additional processes may take place due

to extraneous influences. This is the case of chimneys built with lime mortar. The smoke gases, frequently containing sulphuric anhydride, produce the formation of gypsum in the lime. This invariably results in deterioration. The effect of smoke gases is even more apparent in dolomitic limes, as magnesium sulphate is especially destructive. Therefore, in combining cement with lime, silica should be used which will react with the free lime. Portland cement contains no available silica for this purpose, and surrounding the lime, it prevents its hardening by excluding carbon dioxide of the air, which has no part in the hardening of Portland cement. An admixture of silica corrects these conditions. Mortars exposed to carbonaceous or sea water may be improved by admixtures of silica, as both attack the lime. F.P.H.

Significance of iron to Portland cement. GOSLICH. *Zement*, pp. 446, 447 (1927); *Rock Prod.*, **30** [15], 88 (1927).—G. studied the degree of oxidation of iron in Portland cement, making analysis of the raw materials and of the finished product. The procedure was extremely difficult because complete exclusion of the oxygen of the air was necessary. The following points were established: (1) the blue-black shale contains Fe_3O_4 which maintains its state due to the presence of bitumen; (2) as soon as the bitumen becomes slowly decomposed in the upper layers, due to contact with air, the material becomes yellow; (3) yellow unburned clinker contains Fe_2O_3; (4) the gray-green clinker contains only traces of Fe_3O_4, the iron being present mainly as Fe_2O_3. This discovery was quite unexpected. The fact that iron oxide imparts to the clinker a gray-green color has not as yet received an explanation. When Tornebom's microscopic studies led him to announce that Portland cement was composed of 4 different substances, which were characterized by their crystals and were designated as alite, belite, etc., no mention was made of their chemical composition. It was only established that alite was the predominant crystalline form. Other scientists came to the conclusion that alite consisted only of lime and silica, while belite, celite, etc., also contain alumina and iron oxide Numerous attempts were made to produce alite synthetically from lime and silica. G. maintains that W. Dyckerhoff's dissertation did not solve the problem of the nature of Portland cement. To prove his point he recounts the results of the latter investigation, which are: (1) $2CaO \cdot SiO_2$ fused in an oxyhydrogen blast, has no hydraulic properties; (2) the so-called "residual" melt, consisting of $CaO \cdot Al_2O_3$ hardens, when mixed with water, but soon dissolves to form a paste; (3) the remaining CaO, which cannot be eliminated, is supposed to form a solid solution with $2CaO \cdot SiO_2$; (4) substances 1 and 2, when fused, yield a clinker which does not approach the strength of ordinary clinker; (5) 1 and 2 and 3% Fe_2O_3, obtained commercially, naturally yield a perfect Portland cement. G. is, therefore, convinced that Portland cement is made up of 4 instead of 3 substances, which are CaO, SiO_2, Al_2O_3, and Fe_2O_3. F.P.H.

Retarding the setting of cement by small admixtures of lead oxide. B. GARRE. *Zement*, p. 469 (1927); *Rock Prod.*, **30** [16], 83 (1927).—Portland cement was mixed with lead oxide and 28% water. The mixture was tested with the Vicat needle. Neat cement had an initial set of 4 hrs. 10 min. and a final set of 6 hr. 20 min. The admixture of but .001% PbO retarded the final set to 9¼ hrs. Up to .2% of PbO the cement showed rapid hardening after about 6 hrs. As the admixture approaches .2% hardening becomes slower. Only imperfect hardening is produced when more than 1% PbO is used as admixture. F.P.H.

New test series on the preparation of slag cements. RICHARD GRÜN. *Zement* (52) 952 (1926); *Tonind. Ztg.*, **51** [23], 375 (1927). F.P.H.

Lime in the U. S. glass industry. E. P. ARTHUR. *Pottery Gaz.*, **52** [602], 1284 (1927); reprinted from *Ind. Eng. Chem.*, **19** [6], 711–12 (1927).—For abstract see *Ceram. Abs.*, **6** [9], 376 (1927). E.J.V.

Magnesium oxychloride cements: control of components. A. W. COMBER. *Chem. and Ind.*, **46,** 661 (1927).—During the past 30 years there has been a remarkable development in the use of "magnesite" composition for floors and walls, particularly in the U. S., where the need of standardization in order to secure consistent results was early appreciated. One of the earliest floors of the type to attract public attention was laid in the Austrian pavilion at the Chicago World's Fair in 1893. Chemical analysis is of service only within very narrow limits; the suitability of a calcined magnesite for cement can only be determined by physical and mechanical tests under working conditions. The important component is the "reactive" magnesia; a magnesite analyzing 90% MgO may contain less of the reactive and servicable component than another having only 80% MgO. A standard formula for flooring cement is: calcined magnesite 5 pts. by weight, powdered quartz 5, wood fiber 1, talc 1, red oxide of iron or other coloring material 1. A formula for stucco is: calcium magnesite 1, quartz 2, sand (20–30-mesh) 5. The MgO should be fine enough for not more than 5% to be retained on a 120-mesh screen. The woodflour should be standardized for texture and fineness, and if the wood be pretreated with $MgCl_2$ solution, the strength, saturation, time, and condition of storage should be made constant. The principle of "voids" which underlies Portland cement mixes applies with equal force to magnesian cement. H.H.S.

Cement manufacture in Britain, 1926. T. L. BAILEY. (Ann. Rept. Alkali Inspector). *Chem. and Ind.*, **46,** 665 (1927).—Cement works were very active until the price of fuel became prohibitive. More 250-ft. rotary kilns were brought into operation. Provision is made in the latest designs to pass the coal dust direct to the kiln by a hot-air blast. The adoption of induced draught to supplement chimney draught is extending. No complaints of smoke or dust from cement works were received. In some works special means are adopted to prevent dust during grinding and packing. Electrostatic methods of depositing cement dust are coming into use. H.H.S.

Special cements. J. DAUTREBANDE. *Rev. chim. ind.*, **36,** 121–24 (1927).—A brief discussion of the composition and properties of fused cement (aluminous cement, electrical cement), electro-cement (a high-CaO Portland cement, entirely different from so-called electric cement), and rapid-setting slag cement. (*C. A.*)

Chemical-analytical investigations of lime. N. A. TANANAEV. *Nauchnuie Zapiski* (Russian), 4, 158–72 (1927).—A detailed outline of the analytical methods used in testing lime for its purity. Numerous reactions are illustrated by equations involved in the analytical procedure. (*C. A.*)

The colloidal theory of cements. T. MAEDA. *Jour. Phys. Chem.*, **31,** 933–36 (1927). —In connection with the setting and hardening of Mg oxychloride cements, M. proposes a theory which involves both crystals and colloids. (*C. A.*)

BOOKS

Cement and Gypsum. OSKAR SCHMIDT AND OTTO HAHNLE. (1927) Stuttgart (Konrad Wittwer). 38 pp., 2 M; *Tonind. Ztg.*, **51** [34], 596 (1927). F.P.H.

Lime Burning with Gas, Powdered Coal, or Oil. OTTO SCHAFER. Leipzig: Fr. Voigt 130 pp. (1927). Bound 4 M. Reviewed in *Tonind. Ztg.*, **51** [10], 151 (1927). F.P.H.

PATENTS

Investment composition. CLIFFORD L. CORFMAN. U. S. 1,631,249, June 7, 1927. An investment composition for dental use comprising magnesite as a base and plaster of Paris.

Method of producing articles from compositions of matter. ALBERT BARNES-THOMAS. U. S. 1,638,108, August 9, 1927. A method of producing imitation marble, tiles, slabs, or the like, comprising applying to a molding surface a substance substantially free from gritty materials and containing a substantial percentage of casein to act as a glazer, then applying to said 1st substance a base material to form an integral mass.

Imitation marble, tiles, slabs, and similar material especially for use for decorative purposes in buildings and other places. ALBERT BARNES-THOMAS. U. S. 1,638,109, August 9, 1927. An article of manufacture such as imitation marble, a tile, slab, or the like comprising a facing or surface containing cement and casein, and constituted by an initial film-like surfacing layer and a thicker layer, to which latter is united a concrete-like backing.

Rotary cement kiln. Brit. 268,868; *Rock Prod.*, **30** [16], 83 (1927). A series of 2 or more channels are arranged on the outside drying zone of a rotary kiln. These are in direct connection with the kiln proper; the raw cement material to be dried and combustion gases passing in opposite direction through these tubes. The increased cross-section area reduced the velocity of the flow of the combustion gases and gives more efficient heat transfer. The raw material after drying passes below to a grinding device located in the tubes and thence to the kiln for calcining. F.R.H.

Casein compositions. W. J. STEVENS. Brit. 253,582, March 16, 1925. In forming a composition suitable for making molded electric insulators, casein is mixed with hot H_2O and a solvent such as soda, NH_3, tannic acid precipitated with lime, etc., and cellulosic material such as cotton or tissue paper is stirred into the plastic mass. (*C. A.*)

Enamels

Practical application of inhibitors in pickling operations. F. N. SPELLER AND E. L. CHAPPELL. *Chem. Met. Eng.* **34,** 421–23 (1927).—Small amounts of certain materials added to acid solutions greatly decrease their rate of attack on metals without markedly slowing down their rate of solution of oxide. This effect is more marked with high acid concentration than with low, and is less marked at high temperatures of pickling. This inhibiting action is apparently catalytic. S. and C. list as commercial inhibitors, acid sludge, bran, and materials containing nitrogen bases. Plant tests are cited, showing large savings of acid through the use of inhibitors, in addition to preservation of the metal surface, and reduction of acid fumes in the air. It is noticeable, however, that in the experiments cited the use of inhibitors in every case increased the pickling time appreciably. M.E.M.

The American electric enameling furnace, Hagan system. HANS NATHUSIUS. *Centr. der Hütten und Walzwerke*, **30** [29], 310–11 (1926).—A description of the Hagan electric enameling furnace is given. Its advantages are uniform heat, best heat transfer from the heating elements, highest thermal efficiency through uniform heat distribution, and the best heat insulation; heating is clean and the burning chamber is free from combustion gases, smoke, and dust; the temperature can be set accurately and is automatically regulated; production is 50% higher than in a coal-fired furnace as determined by square feet of surface enameled; complete elimination of waste or the need for repeated firing on account of faulty firing; the enameler can utilize 100% of the hearth surface; exact reproduction of colors and increased value of the final product; elimination of expense for firemen, transportation, and storage of fuel and ashes; reduction of the maintenance and repair costs to a negligible amount; and better utilization of the skill of the service men. E.J.V.

New Leonard plant a model for flexible production. P. T. SEALEY AND G. W. GREENE. *Ceram. Ind.*, **9** [2], 142–51 (1927).—A description of the plant of the Leonard Refrigerator Co. is given. The article is fully illustrated. F.P.H.

Glass

The decomposition of glass by water at high temperatures. G. W. MOREY AND N. L. BOWEN. *Jour. Soc. Glass Tech.*, **11** [42], 97–106 (1927).—Homogeneous glasses

in the forms of cubes and tubing were heated with water for about 20 hours at temperatures of 300 and 550°C and the products examined microscopically to determine the crystalline phases present. The amount of attack of the crown glasses in general corresponded closely to the stability as shown by the Mylius iodeosin test and varied as the alkali content of the glasses. The stability of the barium crowns at high temperatures increases rapidly with increase in the barium oxide content. The common crystalline phase present in the high silica crowns was quartz, while that in the barium crown was $BaO \cdot 2SiO_2$. In some of the high silica crowns and in one of the high barium crowns some of the crystalline materials produced are unknown. The flint glasses of low lead content showed almost complete disintegration, but the stability increased with increasing lead content to such an extent that the glasses of highest lead content showed the greatest resistance of those tested. Quartz was present in the crystalline products of all the flints of lower lead content together with a number of unidentified crystals. The crystalline phase of the glasses of highest lead content consisted mainly of alamosite. Of 6 makes of commercial tubing tested, Jena combustion tubing showed by far the greatest resistance to attack while Pyrex at the higher temperature was completely disintegrated. The crystalline phases resulting from the alteration of the tubing glasses were mainly quartz and $Na_2O \cdot 3CaO \cdot 6SiO_3$, except in the case of Pyrex, the crystals of which consisted of tridymite and boric acid. D.J.McS.

Notes on the glasshouses of Stourbridge. F. BUCKLEY. *Jour. Soc. Glass Tech.*, **11** [42], 106–123 (1927).—A history of glass manufacture in and about Stourbridge during the 18th and the early part of the 19th centuries. D.J.McS.

A critical survey of the methods in use for the analysis of the simpler glasses. W. H. WITHEY. *Jour. Soc. Glass Tech.*, **11** [42], 124–53 (1927).—Glasses are best attacked by fusion with sodium carbonate. Solution with hydrofluoric acid is valuable where speed is essential but the liability of error is greater especially with the alumina determination. The use of potassium carbonate or the double carbonate is not to be recommended. In the case of each separation, W. gives all the precautions and conditions which have been found necessary by various workers to obtain the most accurate results. In the case of most glasses, the separation of the iron and alumina is more effective by the ammonium hydroxide method than by the basic acetate method. The volumetric method using permanganate for the determination of iron is given as suitable for glasses containing more than .25% iron oxide. With glasses of lower iron content the colorimetric method using sulphocyanide or that depending on the yellow color of ferric chloride in acid solution is suggested. It is recommended that the calcium be separated as the oxalate in the usual manner and weighed as the oxide. Magnesium is separated as magnesium ammonium phosphate and weighed as the pyrophosphate. Di-sodium phosphate or microcosmic salt are suitable for the precipitation of magnesium but not ammonium phosphate. The grayish mass of magnesium pyrophosphate should not be moistened with nitric acid to secure complete combustion. The alkalis can be separated by either the Lawrence Smith or the Berzelius methods. The latter tends to give slightly higher results but the former is accurate and much more simple. The potassium is separated as the chloroplatinate or the perchlorate, the latter being slightly the better. Lead glasses are fused with sodium carbonate in the same manner as the soda-lime glasses but the fusion should be conducted at a lower temperature and the top of the crucible kept cool to avoid loss of lead through volatilization. The use of niter is not to be recommended in a lead fusion. The lead is separated as sulphide which is subsequently converted to and weighed as sulphate. Sulphur trioxide is determined on a separate carbonate fusion made in an electric furnace and precipitated as barium sulphate. Arsenic is determined by the method suggested by Allen and Zies. A rapid method of analysis for plant control is given. D.J.McS.

Notes on some methods used in the analysis of glasses. V. DIMBLEBY. *Jour. Soc. Glass Tech.*, **11** [42], 153–72 (1927).—D. stresses the necessity for complete knowledge of the composition of a glass before its quantitative analysis is attempted. Overheating of the separated silica is to be especially avoided in glasses containing considerable iron, titanium, aluminum zirconium, magnesium, or zinc. In the presence of zirconium or titanium, the separated silica must be washed with hot, fairly strong hydrochloric acid before washing with water. When lead is present, it is essential to wash the silica with hot water. Boric oxide, if present, must be volatilized as methyl borate during the evaporation for the silica. In the routine analysis of ordinary glasses the residue from treatment of the silica with hydrofluoric and sulphuric acids can be considered entirely as R_2O_3 if present in amounts less than 2 mg. For accurate work, arsenic should be removed with H_2S before precipitating the iron and alumina. The use of methyl red is suggested as an indicator of the degree of alkalinity for the precipitation of iron and alumina. As some glasses adsorb considerable moisture, this constituent should be determined by ignition at 600°C and the analytical results compensated for the amount found. For the determination of iron when present in a small amount the colorimetric method using sulphocyanide is advised. For amounts of iron exceeding .2%, the titanous chloride method of Knecht and Hibbet gives satisfactory results. Manganese in small amounts can be determined colorimetrically by oxidation to permanganic acid using ammonium persulphate and silver nitrate. When present in large amounts, manganese should be separated from iron and alumina by the basic acetate method and determined gravimetrically. Whenever manganese is present in a glass, the precipitates of R_2O_3, lime and magnesia, should be tested for manganese by the colorimetric method. Titanium in small amounts is determined colorimetrically using H_2O_2. When present in large amounts, titanium is best determined by the method of Baskerville by separating with SO_3 and weighing as TiO_2. Zirconia is separated with the titania by Baskerville's method, the titania is determined colorimetrically, and the zirconia determined by difference. Zinc is determined in the usual way by precipitation with H_2S from a formic acid solution. This element when present is very likely to cause trouble by separation with the other glass constituents. Cobalt is best determined electrolytically. Barium-containing glasses should be fused under such conditions as to avoid contamination of the silica by barium sulphate. Boric oxide is best determined by the method of Sullivan and Taylor. D.J.McS.

The function of arsenic in soda-lime-silica glass. Part II. E. M. FIRTH, F. W. HODKIN, AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **11** [42], 190–205 (1927).—In samples of glass melted in tanks it was found that from 55 to 90% of the arsenic added to the batch was retained in the glass. The greater part of the arsenic was retained in the pentavalent condition. The addition of niter to batches containing varying amounts of arsenic did not cause any pronounced increase in the amount of arsenic retained in the glass but tended to increase the ratio of pentavalent to trivalent arsenic. The use of arsenic in conjunction with niter has some advantage in assisting melting and refining although the effect on the melting is not always definite and although the arsenic alone has no such favorable action. Arsenic added as a boiling agent to the glass after melting is complete has little or no refining value. In the trials, the arsenic added to the batch was almost entirely retained in the glass, while that added as a boiling agent was completely volatilized. The total amount of arsenic retained in the glass remained constant during the refining and cooling-off period, but while the glass was under heat, the ratio of pentavalent to trivalent arsenic decreased progressively. Variations in the amounts of arsenic and niter in the batch appear to have only a little effect on the working properties. The decolorizing action of the arsenic is accentuated by the use of niter in the batch. Carbon added to the batch in amount equivalent to the arsenic present has

little or no effect on the amount of arsenic retained by the glass. When very much in excess of this amount of carbon is added to the batch, the amount of arsenic retained by the glass is reduced but not to zero. The most pronounced action of reducing agents is to lessen the ratio of pentavalent to trivalent arsenic. When 10 parts of carbon were used with 5 parts of arsenic, nearly all the arsenic was retained in the trivalent condition. The glasses made with both carbon and arsenic in the batch had a bluish-green color, the blue tint increasing with the amount of carbon used. To ascertain the possibility of arsenic being extracted from the glass while in use, samples of commercial glasses of relatively high arsenic content were heated with vinegar, sugar solution, and sodium carbonate and each material subsequently tested for arsenic. In every case, no arsenic was found to have been extracted from the glass. D.J.McS.

The function of arsenic in soda-lime-silica glass. Pt. III. The effect of temperature and time. E. M. FIRTH, F. W. HODKIN, W. E. S. TURNER, AND F. WINKS. *Jour. Soc. Glass Tech.*, **11** [42], 205–14 (1927).—The lack of effect, previously reported, of arsenic alone on the increase in rate of melting of soda-lime batch at ordinary melting temperatures holds also when the batch is melted at temperatures as high as 1500°C. No trace of bluish-green color was shown by the arsenic-containing glasses melted at high temperatures even when the iron content of the glass was increased to more than .5% through pot attack. The amount of arsenic retained by the glass from meltings in closed pots at 1500°C even after a founding period of 44 hours is practically as great as that retained when the batch is melted at 1400°C or less. In open pots, the amount of arsenic retained decreased somewhat with increase in the melting temperature but at 1500°C was still greater than 50% of the amount added to the batch. D.J.McS.

The theory and design of plate glass polishing machines. F. W. PRESTON. *Jour. Soc. Glass Tech.*, **11** [42], 214–56 (1927).—A description and comparison of existing types of plate glass polishing machines with an analysis of the machine motions in the process of plate glass polishing and theories to explain the actions taking place in glass polishing and to serve as a basis for the design of glass polishing machines. The runners of a polishing machine tend to take up a rotation in synchronism with that of the table. The main problem in the design of a polishing machine is to so arrange the felts as to get uniform polishing over all portions of the table. The rate of polishing the glass is proportional to the rate at which work is done on each unit of the glass. The rate of polishing on a given element is proportional to the amount of felt passing over this element per second. Scientifically the difference between linear and rotary machines lies not in the shape of the track but in the difference in relative velocities of glass and felt. In linear machines the curve of the rate of polishing the glass from the center of the runner to the edge of a single felt takes the following form:

$$y = \operatorname{cosec}\left(\cos^{-1}\frac{x}{R}\right) \text{ constant}$$

The horsepower required is $\frac{\mu m \omega}{550}\sum nR$ in which μ varies from .85 to .95 in ordinary practice. As the motion of the runners is not restrained, the motions in a rotary polishing machine cannot be predicted on geometrical considerations alone. Numerous examples of differences in number and diameter of felts, relative positions of runners, etc., are analyzed. D.J.McS.

The new British fifteen arm automatic suction bottle machine. F. REDFERN. *Jour. Soc. Glass Tech.*, **11** [42], 257–65 (1927).—R. describes in some detail and gives a number of photographs of a bottle machine of the Owens type. It is claimed that the machine can be operated at a speed of 7 revolutions per minute and makes ware from 2½ to 15 inches in height and for wide mouth ware can take a neck ring of 5¼ inches diameter.

Special attention is given to means of lubrication. The machine is also made in 6- and 10-arm sizes. D.J.McS.

Some further developments in recuperative glass furnaces. T. TEISEN. *Jour. Soc. Glass Tech.*, **11** [42], 265–79 (1927).—Describes with photographs and diagrams new types of recuperators. The tubes are hexagonal and are joined by hexagonal interlocking flanges. The air-channels are made undulating and the side walls of the tubes are provided with spikes or teeth to prevent channelling of the gases. Applications of recuperator designs to pot furnaces and results obtained are given. For compactness and other advantages, one design for large pot furnaces proposes the use of 4 recuperators to each furnace. D.J.McS.

On the surface devitrification of glasses. Part III. Devitrification of alkali silicates. KOZO TABATA. *Jour. Soc. Chem. Ind., Japan*, **30** [1], 14B (1927).—Experiments on the surface devitrification of alkali silicates having the chemical composition of 1 R_2O, $xSiO_2$ have been conducted by T. The method was deduced from T's. view on the surface devitrification of glasses by heat given in *Jour. Soc. Chem. Ind., Japan*, **29**, 473 (1926). (See also *Ceram. Abs.*, **5** [10], 305 (1926).) Five stages of devitrification according to the modes of crystal production on the glass surfaces have been determined: (0) no crystals; (1) a few minute crystals at specified places such as at sharpest edges of cicatrices; (2) many crystals along sharp edges or at cicatrized portion; (3) crystals on all the surfaces, namely, crystals produced on the glass surfaces without sharp edges or cicatrices; and (4) crystals cover the entire surfaces or maximum production of crystals on the surfaces. On plotting the results a straight line was found to connect the 0 points. This was named a "boundary line of devitrification." It was assumed that the compounds present in the melts were always metadisilicates. The dissolving power of each one mol of Na_2O, $2SiO_2$ and K_2O, $2SiO_2$ for silica was determined to be about 0.5 and 4.5 mols silica respectively at the temperatures of the experiments. The dissolving power of mixed alkali silicates for silica was found to be entirely additive. The boundary line of devitrification was named also a "saturation line of silica dissolution." The explanation of the remarkable differences of both alkali silicates and the dissolution of silica has been given as due to the different atomic volumes of both atoms of Na and K. E.J.V.

On the surface devitrification of glasses. Pt. IV. Devitrification of alkali lead silicates. KOZO TABATA. *Jour. Soc. Chem. Ind., Japan*, **30** [1], 15B (1927).—Series of glasses whose composition was 1 R_2O, 1 PbO, $xSiO_2$ were tested. The modes of surface devitrification were carefully observed. The results were plotted using the number of mols of SiO_2 as ordinate and molar percentages of K_2O in alkalis as abscissa. Connecting the points of the same degree of devitrification showed them to make straight lines respectively. The "saturation line of silica dissolution" or "boundary line of devitrification" was found to run parallel to the corresponding line of alkali silicates—$1R_2O$, $wSiO_2$. A possible conclusion given was that the alkali-lead-silicate glasses were constructed with $x(1R_2O, 2SiO_2)+y(1PbO, 2SiO_2)+zSiO_2$. E.J.V.

Fiftieth anniversary of formation of Rodefer Brothers celebrated. ANON. *Amer. Glass Rev.*, **46** [43], 15 (1927); *Nat. Glass Budget*, **43** [12], 3 (1927).—A note regarding the celebration of the 50th anniversary of the Rodefer Glass Co., of Bellaire, Ohio, organized as a partnership, Rodefer Brothers, in 1877. E.J.V.

The manufacture of glasshouse lime. W. F. KING. *Amer. Glass Rev.*, **46** [43], 16–17 (1927).—Only certain limes of sufficiently uniform analysis and with a low enough content of impurities are commercially suitable for glass manufacture. The production of lime is traced from the winning of the limestone by blasting and steam shovel, through the crushing, screening, and firing processes. Gas-fired lime kilns running at a temperature of about 2000°F are used. E.J.V.

Expansion of glass precisely measured, Bureau of Standards reports. ANON. *Amer. Glass Rev.*, **46** [43], 21 (1927); *Nat. Glass Budget*, **43** [11], 19 (1927).—The thermal expansion of pieces of glass less than .007 inch in length has been measured by observing the interfering of light waves. E.J.V.

A. B. Knight has new long tumbler and stemware glazing machine. ANON. *Amer. Glass Rev.*, **46** [44], 17 (1927).—A description of the new machine which is a device for perfecting annealing. The operation of the machine is explained. E.J.V.

Development of the unit leer. W. A. MORTON. *Glass Ind.*, **8** [5], 106–108 (1927); *Amer. Glass Rev.*, **46** [33], 17 (1927).—See *Ceram. Abs.*, **6** [7], 270 (1927). E.J.V.

The flow of glass in tanks. D. J. MCSWINEY. *Glass Ind.*, **8** [7], 155–57 (1927).—Knowledge of lines of flow of glass in tanks is important as this is one of the main factors determining the effective capacity of a tank, the rate at which a color or other batch change can be effected in the tank, and the length of time during which subsequent streaking by the old glass takes place. Laws controlling the flow of liquids similar to water through vessels do not hold strictly in the case of glass in a tank as it is not physically homogeneous throughout. Lines of flow (rate of motion of the liquid in various parts of the container) in a tank of glass vary with the tank construction and to some extent with the pull on the tank but the greatest determining factor is the variation in viscosity throughout the tank. Information as to lines of flow of glass in tanks is obtained by observation of the flow while the tank is in use, from examination of the glass quarried from a tank which has been allowed to cool down without tapping and in which a color or batch change had been made, and by observation of the corrosion of the tank block by the glass. The best method is by examination of the glass quarried from a tank in which a color or batch change had been made. Examination of glass quarried from the side walls of a number of soda-lime tanks shows that circulation does not take place along these walls to any considerable depth. The structure of a tank may undergo such changes during its life as to constantly change the lines of flow during this period, especially in the melter. The crude method of intermittent filling of a tank by hand introduces the main variation from what might be expected as to a normal flow in the tank, namely, a rearward circulation. The reason for and effect of this rearward circulation is discussed. Where a more logical method of filling a tank by means of a continuous feeding device is used, this rearward circulation does not obtain to any extent. Some movement always takes place as a result of the contraction which the batch undergoes in melting, but this is very much less when the batch is fed into the tank in a continuous stream than when it is fed in large piles. E.J.V.

Importance of ductility as a working property of glass. ROY E. SWAIN. *Glass Ind.*, **8** [8], 183–84 (1927).—One of the most important elements entering into and controlling glass-working processes is ductility. A mold charge of glass is usually referred to as a "plastic mass" or a "plastic body" but is not plastic in the same sense as clay, putty, etc., are plastic. It is a heavy viscous liquid and must be worked as such. Ductility enters into practically every important glass-working process. Even in pressing, a close study reveals that the design of press molds is controlled largely by the ductility of glass. The press shops also utilize the ductility of glass to reduce the size of the shear cut by drawing out the neck of the glass before shearing. In finishing pressed ware, ductility plays an important part; articles such as swing-out vases are drawn out from blanks only a fraction of the length of the finished ware. The art of glass blowing is dependent upon ductility for its existence. Practically all the off-hand glass working is made possible by ductility. The production of glass wool-like insulating material, glass canes, and tubing is described, showing the part played by ductility. E.J.V.

Fuel economy in glass works practice. T. C. MOORHEAD. *Glass Ind.*, **8** [8], 185–89 (1927).—Fuel is a very important factor in the production of glass, the coal con-

sumption to produce a ton of glass running from 1.25 tons to as high as 2.5 tons. The percentage of fuel used for the various phases of the operations in a bottle factory are approximately as follows: melting, 60%, power, 18%, annealing, 16%, and heating and auxiliary processes, 6%. In the melting process where approximately 60% of the total fuel is used, the average thermal efficiency is only about 16%. Five principal factors determine the efficiency of the melting process. They are the size and dimensions of the furnace in proportion to the glass melted, the nature of the fuel, the composition (and more especially the color) of the glass being melted, the age of the furnace, and the temperature of the external surroundings, also the skill with which the furnace is operated. The extent to which each of these factors influences the performance of the furnace is described briefly. The possibilities for fuel economy in the annealing and auxiliary processes are pointed out. Consideration of purposes to which fuel is to be applied, the nature of the appliances in which it is to be used, calorific value, and approximate analysis of the fuel will aid in effecting considerable economy. E.J.V.

Glasses for protection against harmful rays. H. MEESZ. *Glass Ind.*, **8** [8], 194–95 (1927); reprinted from *Die Glashütte*, **57** [17], 325–28 (1927).—The glass industry is confronted with a new and difficult, but also interesting problem. A demand has grown up for protective glasses which will shield the eyes from the strong light, ultra-violet rays, etc. On the other hand, there is a demand for glasses which will transmit ultra-violet rays, for instance from hospital authorities. With regard to these properties, glasses may be grouped as follows: (*a*) glasses which absorb ultra-violet rays, (*b*) glasses which absorb both ultra-violet and infra-red rays, (*c*) welding glasses, (*d*) protective glasses used for the observation of furnaces, (*e*) glasses which transmit ultra-violet rays, and (*f*) glasses which absorb X-rays. The German Plate Glass Corporation at Grünenplan produces Ophtasan glasses in many degrees of permeability and color which afford complete protection against ultra-violet radiations. Different glasses of this series absorb all rays of wave length less than 355 $\mu\mu$, 360 $\mu\mu$, and 470 $\mu\mu$, depending on their composition. Two protective glasses opaque to infra-red rays absorb rays of wave length less than 345 $\mu\mu$ and 460 $\mu\mu$, respectively. Glasses for welding absorbing rays below 405 $\mu\mu$ and 550 $\mu\mu$ in wave length are also produced. Glasses for observing melting furnaces require protection against glare as well as absorption of the invisible rays. A nearly ideal glass known as 52 I has a dark blue color and in a thickness of 2 mm prevents the passage of rays up to 365 $\mu\mu$. A glass which transmits rays of wave length of 288 $\mu\mu$ wave length in a thickness of 2 mm is the "Brephos" glass which is being used in hospital windows. Lead glasses with 40, 51, and 65% lead oxide content have been developed, having "lead equivalences" of 12, 18, and 25%, respectively. A plate of glass having a "lead equivalence" of 12% has the same protective action against X-rays as a lead plate having a thickness of 12% of that of the glass plate. E.J.V.

Annealing of glass. J. W. FRENCH. *Nat. Glass Budget*, **43** [4], 8 (1927); reprinted from *Jour. Soc. Glass Tech.*, **11** [41], 10–23 (1927).—See *Ceram. Abs.*, **6** [9], 375 (1927). E.J.V.

Molds made from Dixon's Improved Vanad Iron are highly indorsed. ANON. *Nat. Glass Budget*, **43** [11], 3 (1927).—Though their initial cost is greater than that of molds made of other materials, the much longer life of those made from Dixon's Improved Vanad Iron makes them most economical and desirable. The average life of Vanad Iron molds was found by one manufacturer to be from 300 to 400% longer than those made from any other known material. E.J.V.

Turner gives lecture on progress in glass industry. W. E. S. TURNER. *Nat. Glass Budget*, **43** [12], 10 (1927); reprinted from *Pottery Gaz.* **52** [599], 824–28 (1927).—For abstract see *Ceram. Abs.*, **6** [7], 270 (1927). E.J.V.

Interesting talk on glass. W. C. NIECE. *Nat. Glass Budget*, **43** [12], 23 (1927); reprinted from *Hartford City (Indiana) Times-Gazette.*—An address touching on the discovery of glass and comparing the present and early methods of its manufacture given before the Rotary Club of Hartford City. E.J.V.

The Hartford-Empire Company; its origin, success, and rapid development. ANON. *Nat. Glass Budget*, **43** [13], 3 (1927).—A historical sketch of the Hartford-Empire Co., of Hartford, Conn., which originated in a mechanical engineering business about 1884 and slowly became a producer of glass-working machinery of all sorts. Once this work was taken up the concern developed rapidly. Descriptions of various machines developed are given. The equipment of research laboratories is also described. E.J.V.

Decorated glass that's acid proof. ANON. *Ceram. Ind.*, **9** [2], 152–53 (1927).—The Chicago Glass Co. has developed a process whereby it can decorate glass with permanent colors of almost any variety. The colors are fast to light; unaffected by heat up to 1000°F; and resistant to alkalis and acids. F.P.H.

Red glass for pressed ware. ANON. *Ceram. Ind.*, **9** [2], 155 (1927).—The intensity of the red coloring depends not only on the condition of the glass and its content of coloring materials, but also on the treatment in melting, the temperature of the glass during the handling, and cooling conditions provided for in the annealing leer. It is sometimes necessary to make red glass for pressing in a rather hot furnace. When this is the case the coloring to be used is selenium or selenic acid salts. It is said that the following formula gives a red pressing glass in a hot furnace: sand 220.46 lb.; potash 22.05 lb.; soda 55.11 lb.; calcareous feldspar 33.07 lb.; barytes 11.02 lb.; niter 4.41 lb.; selenium 5.29 lb. Careful control of fire and hot pressing forms aid in keeping rose glass uniform in color. F.P.H.

Physics in the glass industry. W. E. S. TURNER. *Engineering*, **124**, 7 (1927).—Physical means of control of glass manufacture require temperature control, the determination of viscosity and density of the soft mass and the softening point, hardness, elasticity, coefficient of expansion, and electrical conductivity of the glass. The relative cubic expansion coefficients of the component oxides are given as ($\times 10^{-7}$): SiO_2, 0.15; ZnO, 0.21; Al_2O_3, 0.52; MgO, 1.35; PbO, 3.18; CaO, 4.89; BaO, 5.2; Na_2O, 12.96; K_2O, 11.7; B_2O_3, 1.9. English glasses are said to excel in transmission of blue, violet, and ultra-violet light. H.H.S.

Bloom on window glass. J. W. YOUNG. (Ann. Rept. 1926. Alkali Inspector.) *Chem. and Ind.*, **46**, 666 (1927).—Complaint was made, by the burgh surveyor of a Scottish city, about the injury to stonework and window glass by fumes emitted from a chemical works. The glass bore, on the outward surface, a permanent and iridescent bloom, not to be removed by careful cleansing and polishing. It was proved, however, that the chemical works had been inactive recently; the appearance has been observed throughout Scotland, even in districts free from chemical works. H.H.S.

Penetrability of various rays through glass. V. Penetrability of ultra-violet rays through glass of special or complex composition. SHIGEMASA SUGIE. *Repts. Imp. Ind. Research Inst.* Osaka, Japan, **8**, No. 1, 1–26 (1927); cf. *C. A.*, **20**, 3218.—The shortest wave which penetrated through 1.5 mm of Na_2O–MgO glass within the range of 1.4–2.2 Na_2O, 0.25–1.45 MgO, 6SiO_2 was about 270$\mu\mu$. Variations in composition within the range or the substitution of K_2O for Na_2O did not materially alter its penetrability. With Na_2O–Al_2O_3 glass, within the range of 1.4–2.4 Na_2O, 0.1–0.6 Al_2O_3, 6 SiO_2, the shortest wave transmitted was about 260$\mu\mu$. The penetrability of Na_2O–Sb_2O_3 glass of the composition 0.4–1.4 Na_2O, 0.3–1.5 Sb_2O_3, 6 SiO_2 was generally low (299$\mu\mu$–323$\mu\mu$), the lowering effect being due to Sb_2O_3. In 3-component glasses consisting of 1.0 Na_2O, 6 SiO_2, and 1.0 oxide of Mg, Ca, Zn, Sr, Cd, Sb, Ba, or Pb, the

transparency to ultra-violet rays was inversely proportional to the atomic weight of the bivalent metallic element. If 4-component glass is composed of oxides of light metals the penetrability is relatively greater than when it is composed of heavier metals. With 5–9-component glass, the penetrability also depends upon the atomic weight of the component metallic element, *i. e.* the greater the atomic weight the less the penetrability of the glass to the ultra-violet rays. In the 2-component glass of the composition 1.0–2.2 Na_2O, 6 SiO_2 the penetrability was great and the length of the shortest wave of rays passed through was constant and was about 260$\mu\mu$. (*C. A.*)

Crystallization of glass. A. LECRENIER. *Bull. Soc. chim. Belg.*, **36,** 137–48 (1927). —A rare example of crystallization is furnished by a specimen of glass in the collection of the Institut Chimique at Nancy. Analysis of the glass yielded the following numbers: SiO_2 75.54%, PbO 0.37%, $Fe_2O_3+Al_2O_3$ 0.35%, Mn_3O_4 0.25%, CaO 7.51%, MgO 0.18%, Na_2O 14.51%, SO_2 0.43%, Sb_2O_3 traces; total, 99.16%. Spherolites of varying size, the majority, however, being about 4–5 mm in diameter, are formed within the material, and their number increases from year to year. The spherolites have the same composition as that of the surrounding glass. The crystalline phase appears to be cristobalite. On allowing a fused barium crown leger glass (SiO_2 48.08%, As_2O_3 0.57%, BaO 29.83%, Al_2O_3 1.65%, ZnO 8.09%, K_2O 6.87%, Na_2O 1.36%, B_2O_3 3 55%) to cool, a large number of spherolites of devitrification, about 5–7 mm in diameter, were formed within the material. As in the preceding case, the spherolites have the same composition as the surrounding glass. Devitrification was not accentuated by heating at 600°, but was completed on raising the temperature to 700°. The crystalline phase appears to be the silicate, $BaSi_2O_5$. No well-defined crystal which could possibly have acted as a center of crystallization was found in any of the spherolites. Crystal soda glass (Na_2O, PbO, SiO_2) decomposes on cooling with separation of cristobalite. Glasses containing cuprous oxide crystallize to form a vitreous, opaque mass having a characteristic reddish-brown color. The crystalline phases are cristobalite and tridymite. Wollastonite has been found in numerous specimens of plate glass. (*Brit. C. A.*)

Ionometric measurement of the acidity and alkalinity of glasses by means of the Luers quinhydrone potentiometer. A. MAURI. *Giorn. Chim. Ind. Appl.*, **9,** 168–69 (1927).—Tests of the alkalinity, similar to those already carried out by Clark's colorimetric method and by the potentiometric method with hydrogen, have been made on Muranese (Tenax), Neapolitan (Crist. Naz.), and Jena (Fiolax) glasses. The p_H values of the solutions obtained by treating these glasses with water of p_H 5.43 in the cold (at 134° for 1 hr.) are, in the above order, 5.65 (5.45), 4.74 (5.62), and 5.75 (6.33). These results differ in absolute magnitude from, but are parallel to, those previously obtained. (*Brit. C. A.*)

BOOKS

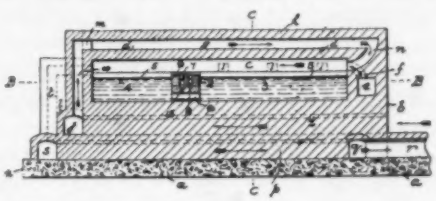
Experiments with an Electrical Annealing Furnace. TH. STASSINET. Publication No. 45 of the Technical Committee of the German Metallurgical Society. Stahleisen M.P.H. Düsseldorf. 13 pp. 1.5M. Reviewed in *Tonind. Ztg.*, **51** [15], 235 (1927). F.P.H.

Census of Manufactures: 1925. Glass and Mirrors. BUREAU OF THE CENSUS. 15 pp. (1927).—Data collected on manufacture of glass and mirrors for the year 1925 are presented, giving general statistics and also some on specific phases such as wage earners, prime movers, generators and motors, products, consumption of raw materials, and equipment. E.J.V.

The Constitution of Glass. Edited by W. E. S. TURNER. Sheffield: Soc. of Glass Tech., 1927. Price *7s 6d.* H.H.S.

PATENTS

Furnace for melting and refining glass and other like purposes. JOHN SCHOFIELD SHAW. U. S. 1,636,151, July 19, 1927. In a furnace for melting and refining glass, a dividing wall, said wall being formed of a plurality of renewable blocks, a plurality of passages extending longitudinally through said wall for receiving a cooling medium, a central wall provided by said passages and cooled upon opposite sides by said cooling medium, a 2nd series of passages extending transversely through said wall whereby the molten material upon one side of said furnace may pass to the other division thereof.

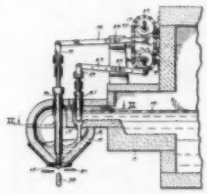


Regulating glass feeders. GEORGE E. HOWARD. U. S. 1,636,564, July 19, 1927. The combination with means for feeding gathers of glass, of apparatus for determining the character of said gathers comprising a gage device past which said gathers are fed, an aperture through which said gage device and gathers may be viewed, a shutter, and means intermittently actuated by the feeding means for actuating said shutter to alternately open and close said aperture.

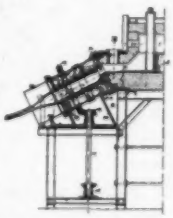
Machine for forming glass articles. RICHARD LA FRANCE. U. S. 1,636,672, July 19, 1927. In a machine for forming glass articles, the combination of a rotating mold carriage comprising a plurality of units, and compound suction gathering molds in each unit disposed in different planes, substantially as described.

Take-down apparatus. THOMAS F. WATERS. U. S. 1,636,794, July 26, 1927. A take-down apparatus comprising a hole-end sling, a hoisting cable and guide rope attached thereto, and a counter-weight cable attached to said sling and supported in such manner as to be capable of moving the sling upwardly along the length of a freshly-drawn cylinder.

Glass feeder. LEONARD D. SOUBIER. U. S. 1,636,875, July 26, 1927. In glass feeding apparatus, the combination of a furnace for molten glass having an extension into which the glass flows from the body of the furnace, said extension having an outlet opening in the bottom thereof, a plunger projecting downward into the glass over said opening, a receptacle beneath said opening into which the glass flows from said opening, said receptacle having a discharge opening in the floor thereof, said receptacle entirely closing the first opening and having side walls converging downwardly toward the second outlet opening, a plunger projecting downward into the glass in said receptacle over the opening, and means to periodically reciprocate said plungers vertically and in synchronism.



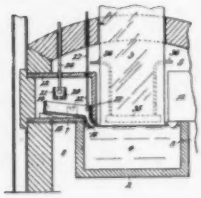
Method and means for the continuous manufacture of glass tubes or rods. PANCRAS SCHOONENBERG. U. S. 1,637,458, August 2, 1927. The method of continuously drawing glass tubes which comprises permitting molten glass to flow into a hollow glass-forming member inclined towards its discharge opening, causing the glass to be distributed on the inner surface of said hollow member by rotating said member so that the glass flows toward the discharge opening by gravity, and always maintaining the interior of the tube out of contact with any solid during the formation of the tube, the glass being then drawn from the discharge opening of the member.



Glassware-transferring device. EDWARD H. LORENZ AND JOHN DAVIS. U. S. 1,637,490, August 2, 1927. In combination with a glass shaping mold, a take out device including means for removing ware from said mold and conveying it laterally a portion of the distance toward a delivery station, and means for receiving the ware from the first-mentioned means and conveying it the remainder of the distance to said delivery station.

Continuous leer. EDWIN E. SLICK. U. S. 1,637,714, August 2, 1927. The combination with a leer conveyer, of a charging conveyer movable across the leer conveyer, means for conveying articles to the charging conveyer, a displacer for moving one article at a time from the charging conveyer to the leer conveyer and means for causing the displacer to move at one speed while transferring the articles from the charging conveyer and at another speed while returning to initial position. The combination with a leer conveyer, of a charging conveyer, a conveyer for loading the charging conveyer and a transfer table between the loading conveyer and the charging conveyer and frictionally driven thereby.

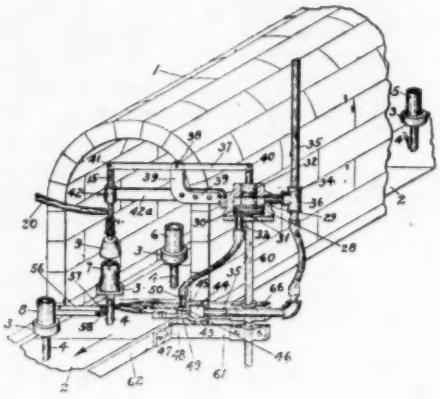
Process of and apparatus for making sheet glass. RICHARD O. STILWELL AND CHARLES H. CHRISTIE. U. S. 1,637,881, August 2, 1927. Sheet glass forming apparatus comprising a forming roll adapted to roll out a mass of plastic glass, an ironing block, means for advancing said ironing block across the sheet of glass as said sheet is being formed by said roll, and means for rotating said block independently of its advancing movement.



Drawing of glass in sheet form and apparatus therefor. EUGÈNE ROWART. U. S. 1,637,961, August 2, 1927. The process of drawing sheet glass, which comprises drawing the main body of the sheet and the two edge portions from separate sources.

Machine for making glass mounts. CHARLES EISLER. U. S. 1,637,989, August 2, 1927. In a head for glass-mount making machines of the type in which portions of suitably held, inner and outer tubes are heated at adjacent ends and the joint completed by the operation of a pressing mechanism, the combination with the pressing mechanism of a movable mandrel conical at its end to engage the heated interior surface of the inner tube and means for moving the mandrel in time relation with the pressing mechanism.

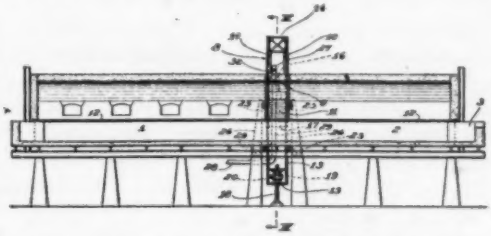
Method of and apparatus for conveying plastic glass. VERGIL MULHOLLAND. U. S. 1,638,593, August 2, 1927. The method of conveying molten glass from a feeder to a shaping machine which comprises depositing the glass on a guideway and admitting gas under pressure to the surface of the guideway to lubricate the same and exert a propelling force on the glass during its passage along the guideway.



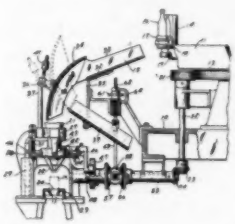
Method and apparatus for shaping articles of glass. VIRGIL O. CORNWELL AND ALBERT MOELLER. U. S. 1,638,620, August 2, 1927. The method of treating glass containers which comprises heating their edges to plastic condition, applying an external annular forming device to such edges, and internally bracing such edges with fluid pressure.

Apparatus for making sheet glass. JOHN H. FOX. U. S. 1,638,728, August 9, 1927. In apparatus for making sheet glass, a casting roll of large diameter mounted for rotation, a driven sizing roll above the casting roll positioned so as to provide a pocket between the 2 rolls for receiving the molten glass to be rolled, bearings in which the sizing roll is journaled mounted for movement toward the casting roll, spacing means mounted to move with said bearings in fixed relation thereto and contacting with the periphery of the casting roll, and a runway for receiving the glass sheet formed between the rolls.

Glass-melting tank. KARL G. KUTCHKA. U. S. 1,638,737, August 9, 1927. The combination with a glass melting tank having a melting end and a working end, of an arch member lying between said ends and having depending walls at the ends of such member and mounted for vertical movement so that a greater or less portion of the member may be moved inside the tank depending upon the vertical position of the member, and means for adjusting the member vertically.

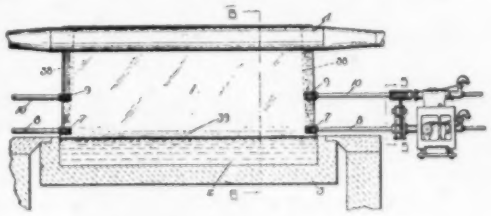


Leer construction. HALBERT K. HITCHCOCK. U. S. 1,638,769, August 9, 1927. In combination with apparatus for intermittently rolling sheets of glass, of a roller leer comprising a high speed section which receives the sheets from the rolling apparatus and a slow speed section following the high speed section, means for driving the rolls of both sections at a relatively low peripheral speed, such means including one way clutch means for driving the rolls of the high-speed section, and other means for driving the rolls of the high-speed section at a relatively high speed, such means including another set of one way clutch means.



Apparatus for transferring glass articles. ALBERT N. CRAMER. U. S. 1,638,920, August 16, 1927. The combination of an inclined chute down which articles are impelled by gravity, and an open inverted trough forming a deflector located beyond the lower end of said chute and positioned to deflect and guide the articles after they leave the chute.

Drawing sheet glass. JOHN L. DRAKE. U. S. 1,639,452, August 16, 1927. In the art of drawing sheet glass from a mass of molten glass, the method consisting in applying longitudinal drawing forces to the sheet edges only at the sheet source, applying supplemental drawing forces to the sheet edges only at a greater drawing speed at points beyond the sheet source, and subsequently applying a still faster drawing force to the entire body of the sheet.



Sheet-glass width-maintaining shield. ENOCH T. FERNGREN. U. S. 1,639,453, August 16, 1927. In sheet glass apparatus, means for drawing a sheet from a mass of molten glass, including width maintaining means, and means arranged beneath the said width maintaining means for shielding the same.

Drawing sheet glass. JOSEPH A. REECE. U. S. 1,639,466, August 16, 1927. The method of drawing sheet glass, which consists in supplying a draw-pot with subsurface glass from a glass-melting furnace, drawing a sheet vertically therefrom, and flowing from said pot any surplus glass contained therein.

Glass. GENERAL ELECTRIC CO., LTD. Brit. 254,175, Aug. 1, 1925. Glass for electric insulation contains PbO and also at least 2% CaO. It may comprise: SiO_2 62, Na_2O 7, K_2O 8, PbO 20, and CaO 3 parts. See *Ceram. Abs.*, **6** [8], 341 (1927). (*C. A.*)

Annealing glass. ILLINOIS PACIFIC GLASS CO. Brit. 254,580, Oct. 30, 1925. In a temperature-controlled leer, annealing is effected by preliminary heating at a relatively high temperature, rapidly reducing the temperature to a point still within the annealing range, to effect further annealing, and then continuously cooling. (*C. A.*)

Glass molding and working. GLASFABRIK AKT.-GES. AND G. STEIN. Brit. 254,330, June 25, 1925. Cast Fe molds in which a pattern has been cut, or other molds or tools for working glass, are hardened by coating their working surfaces with a layer of "chrome." (*C. A.*)

Glass manufacture. Production of metal. A. SIDLER. Brit. 271,136, July 13, 1927. A method of lowering the melting temperature, in making a glass-containing alumina and a high proportion of silica, consists in introducing these materials into the batch in the form of compounds which, when decomposed by the melting heat, release the materials in a very active state. The siliceous compound may be an alkali silicate or silicic acid hydrate, and the aluminous compound may take the form of an aluminate or a salt of aluminium such as a chloride or nitrate. The method is used to make a glass which contains over 80% of silica, at least 3% of alumina, not more than 12% of boric oxide, and not more than 4% of alkali oxide. The siliceous compound is used either in a crystalline or amorphous state and the batch is ground and well mixed by machine. The mixed batch may be pressed into briquettes, with or without a binder, to prevent fine material from being carried away by furnace drafts. The pots or tank blocks must be lined with a material which will not be unduly attacked by the batch, such as zirconia, or they must be made of acid material.

FIG. 1.

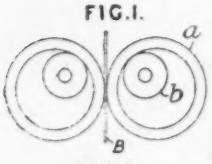


FIG. 2.

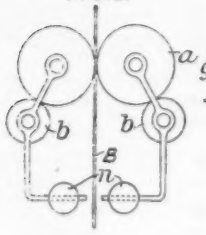


FIG. 5.

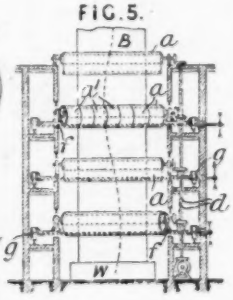
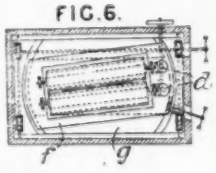


FIG. 6.



Glass manufacture. H. HERMANN. Brit. 271,444, July 13, 1927. Relates to drawing apparatus of the kind in which the glass is lifted vertically upwards in a flat sheet by pairs of opposed rollers, and consists in providing means for enabling the rollers to adjust themselves to variations in the thickness of the sheet and to any warping or twisting of the sheet which may occur. In the construction shown in Fig. 5, a sheet *B* is drawn vertically upwards from a pot *W* by means of pairs of rollers *a* arranged vertically above one another. Each roller *a* may be divided into a number of annular sections a^1, and the whole of the sections are driven by an internal drivingshaft *b*, Fig. 1, on which they rest. The weight of the sections forces them into contact with those of the associated

roller, but the arrangement enables the sections to move apart and adapt themselves to irregularities in the thickness of the sheet *B*, which is gripped between the rollers. The rollers may be solid, and in this case they are so mounted that they can swing about the axes of the driving-shafts *b*, as shown in Fig. 2. They are held in contact with one another, and with the sheet *B*, by counterweights *n* or by springs. Each pair of rollers is mounted on a frame *f*, Figs. 5 and 6, carried by a wheeled truck *g*. The truck can be moved transversely to the plane of the sheet *B* and the frame *f* can be turned about a vertical axis, thus enabling the rollers to be kept in contact with the whole width of the sheet should it become warped. The pairs of rollers are driven by flexible or articulated shafts *d*, and the speed of the rollers is arranged to increase slightly from the lowest to the highest.

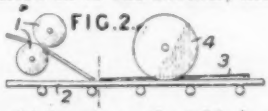
Glass manufacture. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 271,481, July 13, 1927. A flame-tinted glass, particularly intended for electric lamp bulbs, is produced by adding iron oxide and manganese dioxide to a batch for making colorless glass. A suitable foundation batch consists of 54.5 parts of sand, 17.5 parts of soda, 3 parts of niter, 21 parts of litharge, and 4 parts of feldspar. To 100 parts of this batch, 5 parts of niter, 3 parts of red oxide of iron, and 4 parts of manganese dioxide are added. A glass of lighter tint is made by adding 1.5 parts of red oxide of iron, 4 parts of manganese dioxide, and 5 parts of niter to 100 parts of the foundation batch.

Glass manufacture. Forming articles from tubular blanks. A. T. KEPHART. Brit. 271,972, July 27, 1927. Relates to a machine for dividing a glass tube into two shorter tubes with closed ends. According to the invention, the tubes, which may have had their ends formed into finished necks in another machine, are carried one at a time from a magazine in a direction at right angles to their length to a position where they are rotated while they are heated at the part where division is to take place. When sufficiently heated, the ends of a tube are drawn apart to effect division, and are then moved backwards to flatten the bottoms by forcing the heated ends against flat plates.

Glass manufacture. Rolling. NEUE GLASINDUSTRIE-GES. Brit. 272,125, July 27, 1927. Glass plates or sheets for roofing purposes have longitudinal folds along both edges and the middle of each sheet to enable them to be fitted on to one another, the folds tapering from one end of a sheet to the other, as shown in Fig. 1. A plate is formed by rolling apparatus 1, Fig. 2, and is deposited on a moving Table 2 which is fitted with longitudinal ribs 3. A roller 4 which rests on the table has circumferential grooves which correspond in form to the ribs 3. The plastic sheet is rolled between the roller and the table and the required grooves are formed by the ribs 3. The folds in the sheet can also be formed by the rollers 1 and can be given their final form by the roller 4 and the ribs 3.

FIG. 1.

FIG. 2.



Heavy Clay Products

Consumption of power in the heavy clay industry. S. ARTHUR WILLS. *Bull. Amer. Ceram. Soc.*, **6** [8], 235–38 (1927).—Power supply and application is an essential in ceramic industries. The importance of power costs should prompt one to analyze and design the equipment thoroughly and intelligently to avoid unnecessary waste. If one's knowledge in regard to electric power installations is limited, the specialist from the power company should be consulted for help on the power problem. The opportunity for coöperation of various parties interested in power consumption in the clay products industry is clearly shown. E.J.V.

Glut in New York brick market hits Hudson River. ANON. *Brick Clay Rec.*, **71** [2], 98–99 (1927).—The brick industry on the Hudson is suffering from a recession

amounting to more than 25% in New York building. The condition of the small plants is serious. Importations from Belgium also cause trouble in the brick market. E.J.V.

Building is now running on its second wind. GEORGE E. MACILWAIN. *Brick Clay Rec.*, **71** [2], 100–101 (1927).—A survey of building activity for 1927 shows that building is exceeding the demand and a reaction is due to come. E.J.V.

From lumber to sewer pipe. ANON. *Brick Clay Rec.*, **71** [2], 102–104 (1927).—When the Clearfield Lumber Co., of Clearfield, Ky., finished cutting a large stumpage in Rowan county, tests were made on the clay found there, the market and methods of distribution were studied, and as a result of favorable reports the twelve-kiln plant of the Lee Clay products Co., was erected for the manufacture of sewer pipe. Interesting features of the plant are described. E.J.V.

Fishing for orders and catching 'em too. ANON. *Brick Clay Rec.*, **71** [2], 112–13 (1927).—A description of the Hazelton Brick Co., of Hazelton, Pa., brick plant which uses novel sales methods. A fish pond stocked with trout where prospective customers are allowed to fish, and carrier pigeons trained to bring back orders from architects or builders' offices to which they have been shipped with color engravings of different panels manufactured are two novel features. All the plant buildings are built of the brick produced by this Company. E.J.V.

Build up markets on your plant. A. D. COCHRAN. *Brick Clay Rec.*, **71** [2], 114–15 (1927).—The fact that materials other than clay products are often used in clay products manufacturing plants where clay products would serve as well, or better, is pointed out. Examples are cited. Manufacturers must recognize an allegiance to their industry. Neglected outside markets for clay products are suggested. E.J.V.

Chicago Builders have own home. ANON. *Brick Clay Rec.*, **71** [2], 116–17 (1927).—A description of the new Builders Building in Chicago, which was formally dedicated to the good of the construction industry. A permanent exposition of building materials is a feature of the building. Many clay products firms have offices and display rooms. Some of the clay products exhibits are described and photographs thereof are shown. E.J.V.

Steel and clay products for the modern permanent home. ANON. *Brick Clay Rec.*, **71** [3], 180–81 (1927).—A description of a steel framed house with hollow tile and brick walls built in Shaker Heights, Cleveland, Ohio, with a considerable saving of time in construction work, and a result of a stable and permanent building which is fire resistive and immune to the elements. E.J.V.

Pick a few orders in the garden. ANON. *Brick Clay Rec.*, **71** [3], 186–87 (1927).—Suggestions are made for use of clay products as pathways and walls to make attractive and durable garden adornments. This is a fertile field for the brick salesman. E.J.V.

A day in Sibleyville. ANON. *Clay-Worker*, **88** [1], 21–25 (1927).—A description of the plant of the Birmingham Clay Products Co., of Sibleyville, Alabama. Equipment and methods used are discussed. This plant produces both stiff-mud and dry-press brick in various colors. The history of the company is briefly traced. E.J.V.

Factory design and equipment. T. W. GARVE. *Clay-Worker*, **88** [1], 32–36, 60 (1926).—The 5th of a series of articles on this subject. Screening and air separation are dealt with. Various types of screens such as the ordinary gravity type, the Dunlap screen, the piano wire screen, rotary screen, and vibrating screen are discussed in detail. The principle of air separation, and types of installations for air separation are discussed. For other articles in this series see *Ceram. Abs.*, **6** [8], 343 (1927). E.J.V.

The evolution of brick and brickmaking in the United States. GEORGE M. FISKE. *Clay-Worker*, **88** [1], 44–45 (1927).—Another of a series of articles on this subject dealing

with the history of the American Face Brick Association. See *Ceram. Abs.*, **6** [8], 362 (1927). E.J.V.

Preparation of sand-lime brick in England. ANON. *Master Builder* (774), 1 (1926); *Tonind. Ztg.*, **51** [24], 394 (1927). F.P.H.

The prevention of the formation of cracks in drying. ANON. *Master Builder*, (778) 66, March (1927); *Tonind. Ztg.*, **51** [32], 559 (1927). F.P.H.

Preparation of clay pipes. ANON. *Master Builder*, (778), 69, March (1927); *Tonind. Ztg.*, **51** [31], 539 (1927). F.P.H.

Three new German sand-lime brick plants in Hamburg. GEORGE WEGNER. *Rock Prod.*, **30** [16], 65–69 (1927). F.P.H.

What qualifications must a manager of a brick plant have? W. GIECHE. *Tonind. Ztg.*, **50** [11], 161–62 (1927). F.P.H.

The Eckert hollow brick wall. D. W. GERLACH. *Tonind. Ztg.*, **51** [7], 87–88 (1927). —A description of the Eckert hollow brick wall giving the saving in material and labor obtained by the use of this method of brick laying. The bricks are layed on edge with openings in the wall the thickness of a brick and alternate layers are tied. F.P.H.

The use of brick in modern churches. R. L. MEHMKE. *Tonind. Ztg.*, **51** [12], 173–74 (1927). F.P.H.

German Industrial Standard (DIN106) for sand-lime brick. ANON. *Tonind. Ztg.*, **51** [16], 245–46 (1927).—The German specifications covering sand-lime brick. F.P.H.

The testing and properties of sand-lime brick. H. BURCHARTZ. *Tonind. Ztg.*, **51** [19], 289–92; [20], 306–309 (1927).—The following tests are described and the values obtained in testing a number of grades of sand-lime brick are given: (1) outer appearance such as color, form, texture, and size, (2) specific gravity, (3) water absorption, (4) resistance to the action of frost, (5) resistance to fire, (6) heat conductivity, (7) adherence between brick and mortar, (8) strength of mortar work. The values obtained are compared with the corresponding values obtained with ordinary building brick. Two types of mortars are used in the tests namely, (1) cement, (2) lime. F.P.H.

The Arnoud sand-lime brick plant. B. KRIEGER. *Tonind. Ztg.*, **51** [24], 378–81 (1927). F.P.H.

Production of clinker. R. WITTE. *Tonind. Ztg.*, **51** [27], 440–41; [28], 460–61 (1927). F.P.H.

The control of the clay content of heavy clay product bodies. CARL HUTTER. *Tonind. Ztg.*, **51** [29], 485–86 (1927).—The application of a sedimentation method of the determination of the clay content of raw batches that are used in making heavy clay products. F.P.H.

Heat economy in the sand-lime brick industry. A. BEHNISCH. *Tonind. Ztg.*, **51** [33], 570–71 (1927); *Rock Prod.*, **30** [12], 103 (1927).—B. describes changes made at the Falkenberg sand-lime brick plant, Germany, through which effective heat economies were brought about. The operation, using the drum process with 2 Bernhardi presses, had a total capacity of about 40,000 bricks a day. The plant also had 4 curing tunnels, each 27 ft. long and one curing tunnel 47 ft. long, the total capacity being 31,000 bricks. A survey showed the necessity of manufacturing more than this daily output. As the installation had but one Cornwall boiler of 646 sq. ft. heating surface at its disposal, the utilization of heat had to be made as extensive as possible to obviate the necessity of enlarging the steam generating plant. The loaded brick trucks are shoved into the tunnels as commonly practiced. However, as after 6 hours the tunnels are filled, 2 preheating chambers were built onto the tunnels, in which the excess production

of brick is preheated in concrete chambers, excluding undesirable air exposure. When the brick have hardened sufficiently and are removed from the tunnel, the steam is forced into another tunnel. Such steam as may remain after this is directed into a preheater where water is heated. This preheated water is led to a high pressure storage tank. The boiler feed water entering the boiler from this high pressure storage tank has a temperature of about 100 to 120°C. The steam, upon performing the work of preheating the water, is forced through a coil, located in a water tank, and is finally discharged into the preheating chamber mentioned above, where its heat is utilized for the preheating of stored units. The cold water required for boiler feed is pumped into the tank just mentioned, where it is preheated by the steam coil, after which it is forced into the preheater and enters the cycle. This utilization of heat has made it possible to produce 60,000 bricks a day with a boiler of 646 sq. ft., which is an indication of heating at maximum capacity. F.P.H.

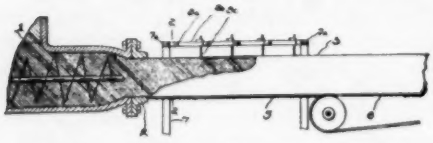
BOOKS

Introduction to Building Science. F. L. BRADY. London: E. Arnold & Co., 1927. Price 7*s*, 6*d*. H.H.S.

Census of Manufactures: 1925. The Clay-Products Industries and Sand-Lime Brick. BUREAU OF CENSUS. 30 pp. (1927).—Data collected on manufacture of clay-products (other than pottery) and nonclay refractories, pottery, and sand-lime brick for the year 1925 are presented in tabular form, giving general statistics and some on specific phases of the industries. Brief descriptions of the branches of the industry are given. E.J.V.

PATENTS

Brick-scoring apparatus. GEORGE W. BOOTH. U. S. 1,636,547, July 19, 1927. Apparatus for scoring brick comprising a plurality of independent scoring members floatingly supported relative to the surface of the brick material; and individual means for yieldingly pressing each scoring member toward the brick.



Facing or preservation of walls and other surfaces. JOHN WILSON DOUGAL. U. S. 1,636,629, July 19, 1927. In the treatment of walls or other surfaces of cement work, stone, brick, concrete, or the like, the steps of maintaining the surface in a damp state sufficient to promote complete hydration of a hydraulically setting cement, spraying a dry cementitious powder capable of setting hydraulically thereon, and applying a hardening solution of a soluble silicate to said surface.

Refractories

Nature and origin of refractory clays. DONALD W. ROSS. *Jour. Amer. Ceram. Soc.*, **10** [9], 704–20 (1927).—A conception of the nature of refractory clays, and a supposition as to the character of their origin.

The origin of bedded Pennsylvanian fire clays in the United States. FLOYD HODSON. *Jour. Amer. Ceram. Soc.*, **10** [9], 721–46 (1927).—The bedded Pennsylvanian fire clays are practically all formed in the Pottsville and Allegheny series, and are associated more or less closely with coal beds, although all underclays are not refractory. Various theories have been advanced to explain the origin of these fire clays, but there seem to be serious objections to most of them. The author believes that the clays here discussed were mostly deposited in swamps and owe their purity to the leaching action of waters containing carbonic and organic acids, which leached out the iron, alkalis, etc. Such leaching would occur chiefly in those portions of the swamp where the water was circu-

lating along channels. Differential leaching would therefore explain variable composition in the underclays.

Notes on the analysis of refractories. W. J. REES. *Jour. Soc. Glass Tech.*, **11** [42], 172–76 (1927).—The necessity of fine grinding of the sample for analysis is greater with refractories than with other silica materials. In a series of fusion of a fire clay containing 3.2% iron oxide and 1.4% titanium oxide the amount of residue separated with the silica when the latter was dried at temperatures from 105 to 120°C increased as follows:

Temperature (°C)	Weight of residue 1 gram sample	Weight of iron oxide	Weight of titanium oxide
105	.006 gm	.003 gm	.002 gm
110	.008	.004	.002
115	.0095	.005	.003
120	.011	.006	.003

For siliceous materials containing not more than 5 to 6% alumina the hydrofluoric acid method is trustworthy. Fusion of finely ground dead burned dolomite and magnesite with sodium carbonate and subsequent solution in hydrochloric acid is recommended instead of direct solution in hydrochloric acid. For the determination of alumina in chrome refractories R. recommends fusion with sodium peroxide, solution in water, and precipitation of the alumina with carbon dioxide. Disintegration of sillimanite or mullite refractories requires very prolonged fusion with sodium carbonate. The use of sodium peroxide instead of sodium carbonate is recommended as giving accurate and more rapid results. D.J.McS.

The testing of refractory materials for resistance to slag corrosion and erosion. A. S. DALE. *Trans. Ceram. Soc.* [Eng.], **25** [4], 326–38 (1925–26).—For abstract see *Ceram. Abs.* **6** [6], 226 (1927). R.F.S.

The thermal properties of refractory materials and a consideration of the factors influencing them. A. T. GREEN. *Trans. Ceram. Soc.* [Eng.], **25** [4], 361–85 (1925–26). —For abstract see *Ceram. Abs.* **6** [6], 226 (1927). R.F.S.

The alteration of silica brick in open-hearth furnace. E. SIEURIN. *Trans. Ceram. Soc.* [Eng.], **25** [4], 401–406 (1925–26).—For abstract see *Ceram. Abs.*, **6** [7], 287 (1927). R.F.S.

The spalling of refractory materials. A. T. GREEN AND A. J. DALE. *Trans. Ceram. Soc.* [Eng.], **25** [4], 428–68 (1925–26).—For abstract see *Ceram. Abs.*, **6** [6], 226 (1927). R.F.S.

Refractories in the gas industry. W. T. GARDNER. *Trans. Ceram. Soc.* [Eng.], **25** [4], 471–85 (1925–26).—The most satisfactory retort setting will carbonize the largest amount of coal per unit of time and yield the maximum possible quantity of gas with a minimum consumption of fuel for heating. Satisfactory refractory material for retorts must be capable of withstanding rapid fluctuations of temperature such as occur when a charge of wet coal is put into a horizontal retort having a surface temperature of 1000 to 1100°C. The material should also be sufficiently tough to resist abrasion resulting from the use of stoking tools or machinery. The essentials of refractories for retort settings are good heat resisting capacity, good heat conductivity, rigidity at high temperatures, resistance to attack of fuel ash, resistance to attack of salty coals, resistance to rapid fluctuations of temperature, and resistance to abrasion. Three classes of refractory materials, fire clay of good quality, siliceous material, and silica, are dealt with in the light of these requirements. The result of the ordinary refractory test by itself is of little value in deciding whether a refractory material other than silica is likely to prove satisfactory for any particular purpose. R.F.S.

The deterioration and failure of glassworks refractories. (*continued*). B. M. PEARSON. *Glass Ind.*, **8** [8], 190–93 (1927).—Temperature and chemical solution are not the only factors causing tank block corrosion. It seems obvious that there must be considerable corrosion owing to the presence of convection currents. The zone of maximum corrosion is a few inches below the glass level. A theoretical explanation of this phenomenon is given. There are several theories as to the cause of the vertical convection currents at the sides of the furnace. A fairly plausible one is that the current is a thermal effect such as occurs in water when heated. Another theory is that due to the fact that the glass at the outside of the furnace is in intimate contact with the block, it will contain more alumina than the rest of the glass, and will be denser than the rest of the glass from this cause. Still another theory is that the addition of alumina to the glass in contact with the blocks by solution of the refractory gives rise to an alteration in the surface tension, resulting in the setting up of convection currents. The effect of convection currents is to increase the corrosion of the block by washing away and removing the slag from the face of the block. The slag so washed away will dissolve up in the glass and fresh parts of the block will be exposed to the further attack of the molten metal. A way of reducing the corrosion of the blocks which has achieved a fair amount of success is by cooling the outside of the furnace by use of compressed air or by water cooling. Cooling the outside of the furnace in this manner will reduce the chemical corrosion of the block by reducing the temperature of that part of the block in contact with the molten glass. A distinctly modern advance in tank block practice is to use thinner blocks, to produce the same effect of cooling the working face of the refractory. The idea of imposing a refractory lining highly resistant to corrosion on the working face of the block, and also on the inside of glass pots is a good one, but due to the fact that the physical constants of such a satisfactory lining will be different from those of the block, a difficulty occurs which would make matters worse instead of improving them. Silica brick, containing 97–98% silica with a little lime as a bond, are used in the crowns of tank furnaces. The wear of the brick in the crown may take place owing to two distinct and separate causes, the cutting action of the flame and the abrasive action of the dust mechanically carried through the furnace in the action, and chemical action. The volatile sodium oxide attacks the crown to form a more or less impure sodium silicate which will in time collect into a drop sufficiently large to fall into the glass below, where it will dissolve. Soft glass, due to its greater soda content, is more severe on both the blocks and crown than a hard glass containing less alkali. Lead glass is very corrosive to glass pots. Soda-lime glass attacks a pot in a similar manner. No cooling of the working face of a glass pot being possible, the corrosion of the glass proceeds rapidly. In the case of covered pots the action is the same as occurs in the case of the attack on the crown of a tank furnace with the exception that in the pot attack, a fireclay material is corroded, whereas in the tank furnace crown practically pure silica is attacked. "Shot-holing" is a phenomenon of chemical attack and corrosion occurring often in the bottom of the pot and more generally at the angle of the junction of the side with the bottom. Evidence strongly suggests that of two pots having the same percentage of the same grog, the one with the higher mullite content in the matrix will be superior in resisting corrosion. See also *Ceram. Abs.*, **6** [8], 347–48 (1927).

E.J.V.

Some fundamental properties of refractory clays at 1000°C. ANON. Bur. Stand., *Tech. News Bull.*, No. 123, p. 8 (1927).—It was found that all of the 17 sagger clays tested in flexure at 1000° showed plastic deformation or "set" under loads applied at the center of 1 by 1 by 10-inch specimen bars. Plastic deformation ranged from 0.0001 inch to 0.0005 inch using a load of 30 lbs./in². Determinations of plastic flow were also made using loads of 60 and 120 lbs./in². and it was found that the plastic flow

of the specimen bar was not proportional to the applied load. The modulus of elasticity was found to be higher at 750°C than at room temperature, but at 1000°C all clays were much less rigid than at room temperature. The transverse breaking strength was greater at 1000°C for all clays except one; a variation in the time-load factor may alter the strength values. The chemical analyses gave only a very general indication of the elastic-recovery and plastic flow properties of the fired clays. The softening point in terms of Seger cones gives a much better indication of the plastic flow at 1000°C. R.A.H.

The effect of water content and pressure of repressing on the porosity of stiff-mud refractory brick. S. M. PHELPS. Amer. Refrac. Inst., *Tech. Bull.*, No. 11; abstracted in *Fuels and Fur.*, **5** [8], 1042 (1927); for abstract see *Ceram. Abs.*, **6** [8], 342 (1927). A.E.R.W.

The manufacture of electrical refractories. W. N. ROBINSON. *Fuels and Fur.* **5** [8], 1031–34 (1927).—The electrical refractories used in supporting heating elements in industrial furnaces and domestic appliances must meet such rigid requirements that careful selection of the raw materials and accurate control of the operating conditions are necessary. R. gives a detailed account of the manufacturing operations and control methods, illustrating it with diagrams and photographs. The greatest independent factor in making possible the production of a uniform product on an economical basis is the recently installed tunnel kiln, which makes it possible to deliver finished products 72 hours after the order has been received and to make a constant stream of shipments thereafter. A.E.R.W.

Report some results on blended refractory materials. ANON. *Brick Clay Rec.*, **71** [3], 179 (1927).—A preliminary report on cyanite-clay and diaspor-clay bodies is given. Though results obtained are cited no definite conclusions are given, the work being presented as a basis for further work on the subject. E.J.V.

The materials for and building of electric furnaces. K. v. KERPELY. *Centralblatt der Hütten und Walzwerke*, **30** [25], 261–66 (1926); **30** [29], 306–309 (1926); **30** [32], 352–55 (1926).—The physical properties of refractory materials, including magnesite, silica, chrome, fire clay, zirconia, bauxite, and Carborundum brick, are listed and compared. The behavior of these refractory brick in the electric resistance furnace is discussed and the different limitations of the value of each are listed. The handling and laying up of the various kinds of brick in electric furnaces to obtain best results are taken up. E.J.V.

Natural sillimanite as a refractory material in the glass industry. W. E. S. TURNER. *Glastech. Ber.*, **5** [1], 4–12 (1927).—The comparison of types of glass made and refractories used prior to and since the war is made. The production of glasses requiring higher heat treatment and having a greater corrosive action has created a need for better glass house refractories. It had been generally recognized that fire clays would alter into a highly resistant material known as sillimanite, prior to the work of Bowen and Greig, if properly heat treated. This was shown, however, to be mullite, $3Al_2O_3 \cdot 2SiO_2$. In America, attempts were made to introduce this into refractories by use of andalusite in the body mixes, while in England Indian sillimanite was used for the same purpose. Experiments were conducted using it in 3 grades of fineness and bonding with 15, 30, and 40% ball clay. The best results were obtained with the fine sillimanite bonded with 30 parts ball clay. Results of shrinkage, porosity, and load tests for various firing temperatures for the different mixes are compared. Pots made of a mixture of 5 parts 100-mesh sillimanite, 1 part 30–70-mesh sillimanite, 1 part 70–100-mesh sillimanite bonded with 3 parts ball clay have a shrinkage so small that they can withstand considerably greater heat shock than fireclay pots can. Results of glass melting tests are

given, showing the slight losses due to corrosion obtained. A sillimanite body used as a coating for refractories improved their service life materially. E.J.V.

New corporation to produce cast tank blocks. ANON. *Glass Ind.*, **8** [8], 200 (1927); *Amer. Glass Rev.*, **46** [43], 18 (1927); *Nat. Glass Budget*, **43** [11], 3 (1927).—The Corning Glass Works and Hartford-Empire Co., have jointly sponsored the creation of the Corhart Refractories Co., to be established in Louisville, Ky., for the purpose of producing on a large scale the cast tank blocks recently developed under the leadership of Gordon S. Fulcher at Corning, N. Y. E.J.V.

Alumina from clay. NAOTO KAMEYAMA. *Jour. Soc. Chem. Ind., Japan*, **30** [3], 44–45B (1927).—Two methods have been proposed for the extraction of alumina from clay. In Yamasaki's method, the clay is first calcined at 600–900°C, preferably at 800°C, and then is treated with 40°Bé sulphuric acid. About 94% of the aluminum and a great part of the iron goes into solution. Crystallization in the form of ammonium alum is resorted to in order to get iron-free alumina. An amount of ammonium sulphate sufficient to convert all the aluminum to ammonium alum is added to the extracted solution heated at about 73°C. The alum crystallizes out on cooling, and may be purified by recrystallization if necessary. Alum crystals are subjected to the passage of gaseous ammonia at 75°C, forming a mixture of aluminum hydroxide and ammonium sulphate from which the latter is separated easily by water extraction, as the aluminum hydroxide here obtained is granular and settles quickly. Sulphate adhering to the aluminum hydroxide can be eliminated by boiling with dilute ammonia water. The aluminum hydroxide should be dried and calcined before being used in the electrolysis. In H. Tanaka's method, the calcined clay is put in an autoclave and treated for about six hours with an aqueous solution of sulphurous acid (about 10% SO_2) under a few atmospheres' pressure at about 73°C, by which treatment the aluminum is extracted as the sulphite, $Al_2(SO_3)_3$. On heating the solution at ordinary pressures the greater part of the sulphur dioxide is liberated and aluminum is precipitated as $5Al_2O_3 \cdot 3SO_2$, which is perfectly white and quite free from iron, and can be made into alumina by calcination. An extraction degree of 70% is said to be obtainable. Simplicity of the process and the purity of the product are claimed to be the chief advantages. E.J.V.

Convection currents and insulation. W. K. BROWNLEE. *Ceram. Ind.*, **9** [2], 153–54 (1927).—B. states that insulated tanks keep uniform temperature, have longer life, and save fuel, and that a tank block fired at higher temperature gives longer tank life. The changes taking place in the melting of glass are traced. F.P.H.

Research on refractories in the United States in 1926. W. STEGER. *Feuerfest*, **3** [6], 94–97 (1927).—A review of the chief contributions made to the refractory literature by the Americans during the year 1926. F.P.H.

Refractory materials in connection with the construction of boiler settings. L. K. RAMSIN. *Feuerfest*, **3** [6], 99–101 (1927).—A summary of the physical and chemical properties of the chief Russian refractories is given in table form. F.P.H.

The importance of the silica inversions to the combustion process and to the behavior of refractories in use. E. STEINHOFF. *Tonind. Ztg.*, **51** [23], 364–66; [25], 400–403 (1927).—A discussion of the stability relations of the silica minerals. The following subjects are discussed in the light of the most recent work on the silica system: (1) the equilibrium diagram of the silica system; (2) the volume changes accompanying the various transformations; (3) reactivity of various modifications of silica in the solid state and in solutions; (4) importance of the silica transformations to refractory brick, (*a*) silica brick, (*b*) clay refractories, (*c*) light refractories; (5) determination of the condition of silica in refractory brick by (*a*) the microscope, (*b*) specific gravity, (*c*) color method, (*d*) the thermal method (heating and cooling curves), (*e*) qualitative determination of the amount of reversible material by the use of a furnace microscope, (*f*) measure-

ment of the expansion, (*g*) the volumetric method. A very good bibliography on the subject is given. F.P.H.

A consideration of the resistance to the action of slags shown by refractory materials. W. MIEHR, J. KRATZERT, AND H. IMMKE. *Tonind. Ztg.*, **51** [9], 121–22 (1927).—The method used in this study was briefly as follows: A cylindrical hole is made in the surface of the brick to be tested and about 50 grams of slag are placed in the hole. The test piece was heated to a temperature about 100°C above the fusion point of the slag. This usually corresponded to 1200–1400°C. This temperature was maintained for one hour and then the test piece was allowed to cool. A section was cut through the brick and the progress of solution and penetration noted. The extent of the slag action on the refractory is defined by 2 numbers: (1) the slag solubility number, and (2) the slag penetration number. Methods of calculating these factors from measurements taken before the slag acts up on the specimen and after the tests are given and their significance is discussed. F.P.H.

The importance of thermal expansion in the valuation of refractory material. W. MIEHR, J. KRATZERT, AND H. IMMKE. *Tonind. Ztg.*, **51** [26], 417–22 (1927).—A description of an apparatus for measuring the expansion of refractory material over the temperature range from 25–1470°C is given. The apparatus consists of a platinum-wound furnace with a lever arrangement to increase the accuracy of the determinations. The test piece is 20 mm in diameter and 70 mm in height and it is supported in the hot part of the furnace by a quartz rod. Another quartz rod is placed on top of the test piece and is allowed to extend outside the furnace where it actuates a lever as the material expands. The apparatus is calibrated previous to the determinations over the temperature range that is to be used. Expansion curves for the following types of refractories are given: (1) silica brick of various degrees of transformation, (2) SiO_2, rich clay refractories (3) Al_2O_3, rich slate, (4) Al_2O_3, rich mullite clay refractory, (5) Al_2O_3, rich corundum clay refractory, (6) Carborundum, (7) zirconia brick, (8) chromite brick, (9) unburned quartzite with 2% lime as a binder and a number of other refractories. The lower the specific gravity of silica brick the greater is the expansion over the interval 150–250°C. In the case of the high alumina refractories the expansion is greater over the range 25–1400°C as the Al_2O_3 content is increased. Expansion curves are also given for fine unburned clays. Carborundum brick expand very little with increase in temperature. Zirconia brick have a greater expansion than Carborundum brick up to 1200°C and then decrease very greatly with increase in temperature. Chromite brick show a greater expansion than zirconia brick and at about 1250°C show a considerable increase. F.P H.

Suggestions for the standardization of the dimensions of arch brick. H. ACKERMANN. *Tonind. Ztg.*, **51** [31], 521–24; [34], 585–89; [35], 609–12 (1927). F.P.H.

Lining of lime kilns. HANS HIRSCH. *Tonind. Ztg.*, **51** [46], 814–16; [47], 836–39 (1927); *Rock Prod.*, **30** [16], 83 (1927).—The lining of a lime kiln or, more particularly, the burning zone of a lime kiln is subject to the action of thermal, mechanical, and chemical agencies. The actual temperatures of calcination vary between 1000 and 1200°C, and sometimes reach 1400°C. The pressure and the motion of the charge produce wear of the lining in a shaft kiln. The lining of the firing zone should be strong and of low porosity. Results showed that the life of the lining satisfactory in rotary kilns, was somewhat endangered in the shaft kilns, and was unsatisfactory in 3 out of 5 gas-fired kilns. Samples of refractories were submitted with answers to the questionnaire. These samples, together with 50 others collected by H. formed the material for extensive tests. The following properties were established (1) chemical composition, (2) fire resistance, (3) porosity or absorption weight per unit volume, (4) expansion when heated to a temperature of Seger cone 14, (5) softening under compressive load, (6) variation of expan-

sion, (7) wear, and (8) resistance to lime. By far the most important property is the resistance to lime. It was tested by using pure limestone and a dolomitic limestone containing 12.9% magnesia. The method follows: A depression, drilled in the sample, was filled with lime (100 g) in powdered form and the sample heated in an industrial kiln to temperatures of Seger cones 14 and 17. The temperature was held at its maximum for a period of 5 hours. The following points were observed, (1) complete solution of the lime meal, (2) formation of a glassy coating on the lime particles, (3) penetration of a glassy mass and, (4) in most cases formation of a slight cracking coat. Considerable variation was observed among the samples. It was notable that a high silica brick with 15% alumina was better than those of higher alumina content. At about 24–31% alumina the lime action, and consequent deterioration, becomes particularly marked. It is still considerable at 36% alumina, and becomes almost negligible for higher alumina content. Parallel tests were made with sintered magnesia, silicon carbide, silica, and the natural minerals: quartz, as well as 3 high alumina refractories: Dynamidon, corundum refractory, and natural sillimanite. It was found that basic materials, such as magnesite and high alumina mixtures, as well as quartzy material, quartzite, and silica, providing they have sufficient density, are highly resistant to lime even at high temperatures. Chemical reactions involved take place between lime, alumina, and silica. The products of reaction are characterized by low points of fusion and result in the formation of a glass. The destructive action is particularly pronounced when alumina and silica are both present and react with lime simultaneously. It is further increased by the presence of magnesia. F.P.H.

The refractory industry as a chemical problem. HANS HIRSCH. *Zeits. angew. Chem.*, **47** (1926); *Tonind. Ztg.*, **51** [37], 643–45; [38], 664–66 (1927).—A description of the relation of the phase-rule diagrams to the practical problems of the refractories industry. The importance of the microscope to the refractories industry is stressed. F.P.H.

Firebrick industry of Stourbridge. ANON. *Brit. Indus.*, **10,** 287–89 (1927).—Stourbridge, Worcestershire, in addition to being the center of the flint glass industry, is the home of a firebrick trade which dates from the 16th century, when refugees from Europe erected a factory on "Hungary Hill." The yearly output is now 250,000 tons. Since the seams dip sharply, the clay is mined like coal. The seams, though all free from fluxes, differ considerably in $SiO_2 \cdot Al_2O_3$ ratio and in density and porosity after firing, thus allowing for a great variety of clay mixtures which are adjusted to meet different demands. H.H.S.

Manufacture and use of silica bricks. R. JORDAN. *Corr. d. Ceram.*, **7,** 15 (1926).—Details of manufacture are given. A good silica brick must withstand a temperature of 1750° for at least an hour. Proper choice of raw materials is a decisive factor. Inversion of the quartz should be practically complete after the first fire. A firing temperature of 1400° is considered sufficient, and a normal firing schedule requires 2–3 days preheating, 1 day high temperature, 7 days cooling. Periodic kilns are the most suitable. (*Trans. Ceram. Soc.* [Eng.])

Simplified method for determining melting points. M. SPETER. *Chem. Weekblad*, **24,** 269 (1927); cf. *C. A.*, **20,** 521.—A cap is sealed to the inside tube which fits well over the outside tube. (*C. A.*)

BOOKS

Clinker, Its Applications and Preparation. KARL DÜMMLER. Halle A. S. Wilhelm Knapp. (1926) 63 pp. Bound 6.8 M. Reviewed in *Tonind. Ztg.*, **51** [18], 279 (1927). F.P.H.

Preparation and Properties of a New Light Refractory from Cristobalite. E. STEINHOFF. Publication No. 95 of the Technical Committee of the German Metallurgi-

cal Society. Stahleisen m.b. H. Düsseldorf. 10 pp. 1.2 M. Reviewed in *Tonind Ztg.*, **51** [13], 203 (1927). F.P.H.

PATENTS

Process of treating aluminous ores. RICHARD MOLDENKE. U. S. 1,637,451, August 2, 1927. In the process of recovering aluminum from alunite ore, the steps which comprise converting a portion of the aluminum in the ore into a potassium alum, separating the potassium alum therefrom, converting the remaining portion of the aluminum contained in the ore into an ammonium aluminum alum and treating the potassium alum and ammonium alum thus formed with ammonia to convert same into aluminum hydrate.

Alumina and aluminates. AKTIESELSKAPET NORSK ALUMINIUM CO. Brit. 252,399, May 23, 1925. Ca aluminate slags are leached with a solution of alkali carbonate containing some caustic alkali (the total alkali present being slightly in excess over the alumina dissolved). The aluminate solution thus formed is treated by the Bayer process to precipitate alumina and the mother liquor is partially carbonated (leaving about 10% of the alkali in the caustic state); the separated solution containing 8–9% total alkali, may be reused. A solution containing only 3–4% total alkali may also be used. (*C. A.*)

Titanium oxide. J. BLUMENFELD. Brit. 253,550, June 11, 1925. A solution obtained by treating Ti ore such as ilmenite with H_2SO_4 is cooled, *e.g.*, +5 to −5° to separate crystals of $FeSO_4$; the solution is then hydrolyzed without dilution and on cooling to room temperature no further separation of $FeSO_4$ occurs. (*C. A.*)

Refractory bricks. SCHEIDHAUER AND GIESSING AKT.-GES. Brit. 253,947, June 22, 1925. Binding clay in the form of a slip produced by the addition of alkali is added to ground chamotte; the mixture is molded and fired. (*C. A.*)

Furnace bricks. R. PORCHEROT. Brit. 272,466, August 4, 1927. Roofs or refractory walls of furnaces are formed of blocks so shaped that a network of air-circulating passages is formed in those parts which are outside the furnace. The upper ends of the brick are reduced and a trough-shaped cavity is provided to receive the end of the iron suspension rod. In cases where forced circulation is used, the recesses are channel-shaped.

Terra Cotta

Some observations on terra cotta physics. H. SPURRIER. *Jour. Amer. Ceram. Soc.*, **10** [9], 686–92 (1927).—An apparatus for determining a representative "over-all" coefficient of thermal expansion of terra cotta under service conditions is described. Observations made show a decided contraction upon wetting the terra cotta and the temperature must be raised for the regaining of the original length. It is probable that the extent of mycelial capillaries is the determining factor of the magnitude of contraction. Further data obtained are presented and discussed.

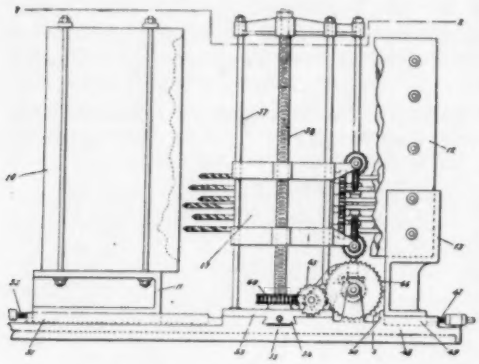
Thirty carloads of stoneware per week. ANON. *Ceram. Ind.*, **9** [2], 161–63 (1927).—A description of the 2 plants of the Red Wing Union Stoneware Co. is given. All clays are washed in these plants and steam is used in the agitators to decrease the time of filtering. F.P.H.

Stucco and ceramic building material in the present architecture. PHILIPP DANNER. *Tonind. Ztg.*, **51** [10], 135–37 (1927). F.P.H.

The water permeability of roofing tile. DAFINGER. *Tonind. Ztg.*, **51** [33], 561–64 (1927).—A description of a simple method to determine the water permeability of roofing tile is given. The results obtained on a great number of tiles are shown. F.P.H.

PATENTS

Method of and apparatus for making sculptures. MARIO SCHIESARI. U. S. 1,636,149, July 19, 1927. In a machine of the class described, the combination, with an axially movable carving tool, and a traveling carrier therefor, of means controlling the axial movement of said tool, independently of said carrier, as said carrier travels along a predetermined path, transverse to the axial movement of said tool.



Method for the production of a cold glaze upon building material, such as concrete, sandstone, clay, brickwork, and the like. KARL FRIEDRICH. U. S. 1,636,860, July 26, 1927. A method for producing in the cold state a permanent thin glazelike coating on building material consisting in preparing a mixture of cement, water, and an emulsion of zinc soap, and in painting the building material with a thin coating of this liquid.

White Wares

Simplification of porcelain insulators. ANON. Bur. Stand., *Tech. News Bull.*, No. 123, p. 4 (1927).—A simplified practice recommendation covering varieties of one-piece porcelain insulators was adopted by a general conference of representatives of the industry, held under the joint auspices of the National Committee on Metals Utilization and the Division of Simplified Practice. Program provides for a total reduction from 272 varieties to 210, producing an annual saving of approximately $400. R.A.H.

Further investigation of feldspar. ANON. Bur. Stand., *Tech. News Bull.*, No. 123, p. 9 (1927).—Thermal expansion observations on 2 series of semivitreous bodies fired to cone 8, using 2 different formulas, one developed by the Bureau and the other suggested by the Whiteware Advisory Committee. The data indicate: (1) a very noticeable increase in rate of expansion in the range 560 to 600°C for specimens of all firings; (2) all bodies containing the high potash feldspar show the smallest percentage of expansion at 700°C for all of the different rates of firing and cooling used. The expansion appears to increase in Na_2O content of the feldspar, the relation being affected by the uncombined silica content also. The expansion for the high potash bodies is lowest when fired to cones 8 and 10 and highest when fired to cone 4 with a difference of about 0.04%. R.A.H.

Little kinks that help put quality in ware. ANON. *Ceram. Ind.*, **9** [2], 159–60 (1927). —A description of the plant of the Onondago Pottery Co. is given. A very efficient plaster container is described. Dust arising from the blunger is removed by suction and canvas curtains catch any particles which may be blown by a cross-draft. F.P.H.

Data on the properties of clay and kaolin that are required in purchasing these materials. ANON. *Tonind. Ztg.*, **51** [6], 71–72 (1927).—A description of the essential data that are required when purchasing clay. The tests required are given in table form. F.P.H.

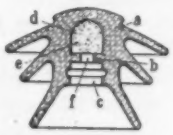
The preparation of hand-molded tile in Greece. FRITZ NEUMAN. *Tonind Ztg.*, **51** [13], 193 (1927). F.P.H.

Data on the properties of clay and kaolin that are required in purchasing these materials. ERNST BUSS. *Tonind. Ztg.*, **51** [20], 303–304 (1927).—B. considers the

following data are required by the purchaser of clay (1) notation of raw material, (2) locality, (3) condition of delivery, (4) size, (5) date and kind of sample taken, (6) sieve analysis, (7) drying shrinkage, (8) chemical analysis, (9) rational analysis, (10) properties of the fired clay, such as: (*a*) firing shrinkage, (*b*) color, (*c*) sintering. F.P.H.

Whiteware. EDUARD BERDEL. *Tonind. Ztg.*, **51** [28], 457–59; [30], 503–506 (1927). —A discussion of bodies and glazes of china ware, stone ware, and porcelain and decorations for these types of ware. Several body and glaze formulas for each type of ware are given. The developments that have taken place in this branch of ceramics since Seger's time are traced. F.P.H.

PATENTS



Method of manufacturing electric insulators. EUGEN REINHOLD CARL BOELCKE. U. S. 1,636,282, July 19, 1927. The herein described method of manufacturing electric insulators, which consists in molding the insulator with a cavity, drying the insulator, putting into said cavity insulating matter which does not expand when being baked, and baking the insulator.

Pottery. J. W. MELLOR. Brit. 253,184, March 9, 1925. In making pottery when the body and glaze are both fired at the same time in the glost oven, the composition of the body is so made that it matures at the same temperature as the normal glaze. Ball clay 20, china clay 20, flint 44, and stone 16 parts may be mixed in the grinding mill with 2¼% of a mixture of Ca or Mg borate 1 and Na silicate rich in SiO_2 2 parts, for making tiles. For electric insulators and fittings, the same flux may be added to ball clay 36, china clay 12, flint 2, feldspar 31, and stone 19 parts. (*C. A.*)

Equipment and Apparatus

Bringing research up-to-date. R. D. COOKE. *Bull. Amer. Ceram. Soc.*, **6** [8], 227–31 (1927).—A discussion of some new tools for the research worker which have come into use within the past 10 or 15 years, but which have not been accepted as fully as they should be in order to be strictly up to the minute in research methods. These include the microscope, hydrogen ion, colloid chemistry, and physics, each being discussed separately. Research methods should be kept up-to-date by making the best possible use of new ideas and by being prepared to recognize new ideas when they appear. E.J.V.

Apparatus that has improved our enamel. L. S. WEIMER. *Bull. Amer. Ceram. Soc.*, **6** [8], 233–34 (1927).—Raw materials taken from the bins are dumped into a mechanical mixer, then run into a bucket which carries them to rotary smelters by trolley. The frit is milled to uniform fineness by direct-connected mills. The enamel is accurately weighed for dipping and fired for a specified time controlled by an automatic timer. Then transfer work is done using an electric oven for drying. E.J.V.

Laminations—a scientific study. J. E. KIRCHNER. *Brick Clay Rec.*, **71** [2], 106–10 (1927).—The fundamental laws of physics concerning friction are explained briefly. The work that is done when a clay column is pressed through a die is calculated. It is shown how the correct length for any certain die may be determined. The development of lamination due to the difference in velocity of the inner and outer sections of the clay column is discussed. The flow of clay in many respects follows the law of hydraulics. The flow in a column may be made even by (1) lubrication of the sliding surface, (2) retardation of the speed of the column in the center by some mechanical device, and (3) by equalization of velocity differences by use of a multi-stream die. Secondary clays being more liable to laminate than primary clays it is advisable to mix sand or grog with such clays. The use of spacer-rings between the auger barrel and die gives the polished

surfaces a chance to knit together before they are forced to slip on each other because of velocity differences in the die. The pushing force in the cylinder must be evenly distributed over the whole section as with a piston motion. The simplest way to remedy lamination is to destroy the polished surfaces created by the auger, either by inserting several arms diagonally in the spacer ring or by placing a perforated sheet between the auger barrel and die. E.J.V.

Laminations. DAVIS BROWN. *Clay-Worker*, **88** [1], 28–30 (1927).—The causes of lamination are listed. The effects of using 1-, 2-, 3-, and 4-bladed augers are discussed. Various means of preventing lamination, such as a thin steel cross bar in front of the auger, extended hub augers, breaker bar revolving in a direction opposite to the auger, and rings with knives which cut the clay column, are discussed in some detail. E.J.V.

Wisconsin firm perfects new screen. ANON. *Clay-Worker*, **88** [1], 51 (1927).—A description of a new improved vibrating screen perfected by the Universal Vibrating Screen Co., Racine, Wis. E.J.V.

Note on modern clayworking machinery as used on the Continent. H. M. RIDGE. *Trans. Ceram. Soc.* [Eng.], **25** [4], 520–27 (1925–26).—During recent years box feeders have been almost universally adopted on the Continent for feeding clay, and the results are extremely satisfactory. The box feeders are frequently used for mixing 2, 3, or 4 kinds of materials, their length being divided into several compartments. Various users say that, as a result of having installed box feeders, their output of brick has been increased by 20 to 35%. Many works on the Continent use 2-deck grinding pans. The power taken by the double-deck pan is only little more than with the type usually employed in this country, but disintegration and mixing are more efficiently done. Large heavy crushing rolls running at high speed are fashionable. The rolls are separately belt driven and are set close together. The speed of the one roll is 140 revolutions per minute and of the other 110 revolutions per minute. In spite of the efficient and cheap labor available, kiln coal feeders are employed in many works. For an ordinary kiln, 20 to 30 of these feeders are used, being moved from one firing hole to another as required. Without alteration to the kiln or the products, the fuel consumption was reduced in one plant by $\frac{1}{4}$ to $\frac{1}{3}$ and that, where desired, the kiln output has been increased by 15 to 20% as compared with the former practice when the coal was fed by hand, and one owner says that the initial outlay was saved in 9 to 10 months. A light type of scraper excavator is largely used in the clay pits and its use is extending rapidly. The traveling chains are fitted with a number of cutters which detach the clay in small pieces from the face so that the lumps fall downward in the same direction as the cutters move. Generally these excavators are electrically driven and one man looks after the whole apparatus except when the track is being moved. Owing to the small weight, the initial outlay is small and working cost low. The machines are efficient and easily handled. As a thin cut is taken right down the clay face, a regular mixture of all the different layers is obtained, while at the same time the material is cut up into small fragments so that the work required after excavation is appreciably reduced. R.F.S.

Conveyers replace fifty men. HARLEY A. LEE. *Ceram. Ind.*, **9** [2], 156–58 (1927).—A description of the conveyer system of the Mosaic Tile Co. where 2270 ft. of conveyers handle 9000 saggers and increase production 33⅓%. The following specifications are given for a conveyer system that would do the work of 50 men: (1) green tile in saggers must be carried without jarring or breaking, (2) freshly dipped tile must be carried to kiln cars without rubbing, (3) the conveyer must carry warm saggers from the kiln cars, (4) the combined units should be able to handle 9,000 saggers an hour, (5) there should be a combined elevator and lowerator for handling fragile shapes from the mold room on the second floor, (6) the conveying speed should be 50 ft. per min., (7) the entire system should be reversible and flexible. F.P.H.

When to use ball, roller, and plain bearings. W. F. SCHAPHORST. *Rock Prod.* **30** [15], 64–65 (1927).—A chart for rapid determination of friction-horsepower of bearings is given. F.P.H.

A comparison of German and English standard sieves. ANON. *Tonind. Ztg.*, **51** [28], 459–60 (1927). F.P.H.

Hardness testing. R. G. C. BATSON AND G. A. HANKINS. *Engineering*, **124**, 24 (1927).—The results of hardness determination by means of diamond cones, Brinell balls, and the Rockwell method, were investigated. For very hard steel, the diamond cone gives good results at angles of 120° and loads of 100 kg, but for softer materials, the coefficient of friction or adhesion μ must be known. H.H.S.

Methods of temperature measurement with thermoelements. ANON. *Z. Metallkunde*, **19**, 144–48 (1927).—A discussion of direct and indirect measurement of the e.m.f. of thermoelements, their sources of error and possible accuracy. (*C. A.*)

The theory of the water pump. W. FRIEDRICHS. *Glas. u. App.*, **7**, 161 (1926).—F. dealt mathematically with the theory of the ordinary water vacuum pump, considering its dimensions for various water capacities, special pumps for high performance, efflux from jets, back diffusion and its repression by vortex action, and the "running back" of the pump and its regulation by a conical outflow nozzle. (*Jour. Soc. Glass Tech.*)

Calculation of the mercury content and scale length for thermometer blowing. T. ZIENER. *Glas. u. App.*, **8**, 1 (1927).—Z. showed how to calculate from the known dimensions and characteristics of one thermometer the bulb capacity and position of given scale divisions of other thermometers to be blown. This was especially useful when making instruments with fused-in platinum contacts. (*Jour. Soc. Glass Tech.*)

Lubricants for ground glass joints. ANON. *Ind. Eng. Chem.*, **18**, 1279 (1926).—Lubricants were required to withstand the action of the strong reagents used in gas analysis. "Stanolind" or heavy liquid paraffin oil was found superior to petroleum jelly as basic material. The following withstands the reagents used in the Orsat apparatus: Parawax (6 parts) is melted over the water-bath and dissolved in low-boiling petroleum. "Stanolind" is added (5 parts), and the solvent evaporated with stirring. Ceresin in place of Parowax gives a less stable but more greasy lubricant. The following were suitable for pressure lubricants: Parowax, heavy paraffin oil, latex crepe (2 : 5 : 1); heavy paraffin oil, latex crepe (3 : 4); beeswax, lanolin (1 : 2); heavy paraffin oil, beeswax (1 : 1). The latex crepe should be dissolved in ether or light petroleum before incorporation. As special lubricants, the following were used: (1) fuming sulphuric acid or phosphoric anhydride, for bromine or acid fumes, (2) molasses or glycerol (wax-free), (3) petroleum jelly, (4) deflocculated graphite, for metal joints. (*Jour. Soc. Glass Tech.*)

Special ball mill. C. P. *Corr. dei Ceram.*, **6**, 184 (1925).—A mill working on the Hardinge principle is described. (*Trans. Ceram. Soc.* [Eng.])

New plant equipment and apparatus. E. E. URBSCHAT. *Keram. Rund.*, 34, 273, 307, 325, 345, 358 (1926).—The exhibits at the Leipzig Spring Fair are discussed under the headings: raw materials, manufacturing processes and plant, works construction, finished products. (*Trans. Ceram. Soc.* [Eng.])

The Weigner elutriator and its practical applications. H. GESSNER. *Kolloid-Zeit.*, **38**, 115 (1926).—The Weigner elutriator is essentially a sedimentation apparatus. By its use a continuous distribution curve can be obtained with disperse systems containing particles between 2 and 0.002 mm in diameter. The apparatus is fully described. (*Trans. Ceram. Soc.* [Eng.])

Drying and drying equipment in the ceramic industry: the importance of control of temperature, humidity, and ventilation. ANON. *Sprechsaal*, **59**, 139 (1926).—Old and new types of equipment are described and illustrated. Much larger volumes of air can be utilized with the ejector system than with others. Evaporation from the surface

must not proceed more quickly than the movement of moisture from the interior to the surface. Various types of automatic control apparatus are described. A method of determining the highest possible rate of drying is put forward. (*Trans. Ceram. Soc.* [Eng.])

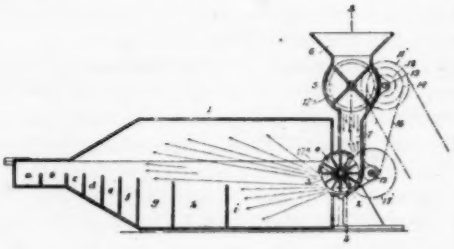
Magneting machines for pottery and glass raw materials. ANON. *Sprechsaal*, **59**, 171 (1926).—Various types of machines adapted for different industrial purposes and constructed by the Krupp-Gruson concern are described and illustrated. (*Trans. Ceram. Soc.* [Eng.])

BOOK

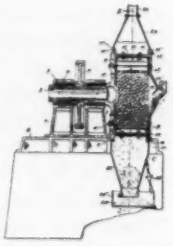
Der Zugversuch. G. SACHS AND G. FIEK. Leipzig: Akademische Verlagsges. 1927. Price 12 *m.*—Apparatus and methods of determining tensile strength. Reviewed approvingly in *Engineering*, **31** (1927). H.H.S.

PATENTS

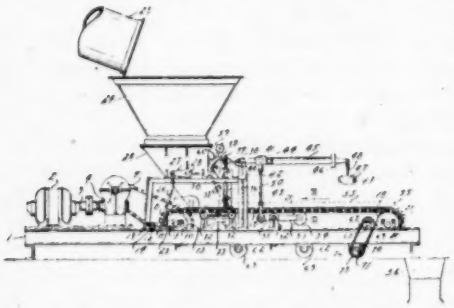
Method and apparatus for mixing, grading, and sorting granular and pulverulent material. EMILE SPRENGER. U. S. 1,636,081, July 19, 1927. Apparatus for mixing and grading granular materials, comprising in combination a horizontal grading chamber having an outlet aperture at one end thereof, a centrifugal distributor, a casing for said distributor having a delivery aperture facing a portion of the distributor circumference and opening into said chamber, a feed aperture facing another portion of the distributor circumference, and an intake aperture facing one side of the distributor, and a box open to the outlet aperture of said chamber and to the intake aperture of said casing.



Ball mill. WILLIAM M. BARKER. U. S. 1,636,585, July 19, 1927. A ball mill including a rotatable drum having opposite drum heads, a sole and relatively short supporting trunnion on one drum head, and a sole bearing bracket for the trunnion, a material inlet orifice in the other drum head, a removable blower case about the drum, communicating openings between the drum and the case, a material outlet for the case, and a separate air outlet for the case.

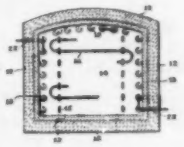


Continuous weighing apparatus. ALFRED F. COOKE. U. S. 1,638,244, August 9, 1927. A hopper having a bottom opening, endless traveling plate providing a movable closure for the opening, sustaining means for the plates at the opening, a series of seats movable with the plates, an additional plate sustaining shiftable means including a toothed wheel coacting with said plate seats, said hopper having clearance on the side thereof toward said additional sustaining means, a gate for varying said clearance and connected to said additional sustaining means to be adjusted thereby, and a toothed wheel drive positively inter-

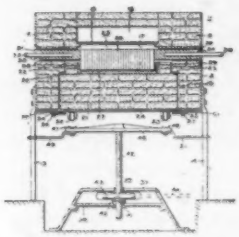


locked with the plate seats for driving the series of plates from the hopper toward said additional sustaining means.

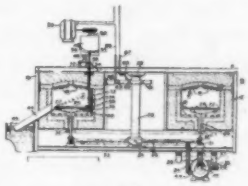
Electric resistance furnace. HERMAN M. BIEBEL. U. S. 1,638,822, August 16, 1927. In an electric furnace, in combination, a preformed, relatively heavy resistor member comprising a plurality of end-connected substantially parallel-extending straight convolutions, and a plurality of spaced hook members removably mounted in and interlocked with a wall of said furnace for supporting said resistor member.



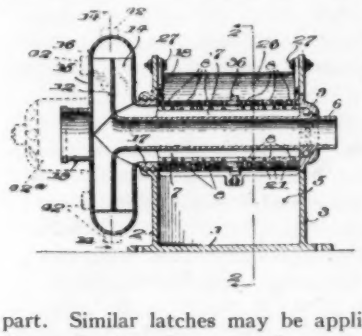
Removable furnace heating unit. EDWARD J. BRANNIGAN. U. S. 1,638,826, August 16, 1927. In an electric furnace, the combination with an open-bottom refractory furnace structure, and a plurality of terminal electrodes mounted therein, of a refractory closure member for said structure movable into its operative position in a substantially vertical direction, and a resistor member mounted on said closure member and engageable by said electrodes when said closure member is in its proper operative position.



Furnace. ALVIN D. KEENE. U. S. 1,638,937, August 16, 1927. In a furnace, the combination with a movable hearth, of means for jarring said hearth.



Grinding and separating apparatus. PAUL L. CROWE. U. S. 1,639,214, August 16, 1927. An apparatus of the character set forth comprising a base, a grinding cylinder journalled on said base and having a plurality of apertures therein, a crusher plate disposed in operative relation to said cylinder, means for yieldingly urging said crusher plate toward said cylinder and means for creating an air draft through the apertures in said cylinder to withdraw the finely divided material therethrough.



Pottery molds. J. F. CROSS. Brit. 258,091, Sept. 23, 1925. Spring latches are provided between the parts of a mold to lock them in assembled position. The 2 parts lock automatically when the upper part is dropped on to the lower part. Similar latches may be applied to 3-part vertically divided molds. (*Trans. Ceram. Soc.* [Eng.])

Molds for pottery. H. L. HOLDCROFT. Brit. 258,175, March 30, 1926. The upper part of a horizontally-divided 2-part mold for jolleying pottery is provided with hook shaped members coöperating with key-holed slots on the lower part of the mold to lock the 2 parts together. (*Trans. Ceram. Soc.* [Eng.])

Pottery molds. CANNING POTTERY CO. AND F. BOURNE. Brit. 264,307, Dec. 28, 1925. The 2 parts of a horizontally divided mold are locked together during the jolleying operations by means of lugs or projections formed on the one part, which engage slots, openings, or cam surfaces on the other part. (*Trans. Ceram. Soc.* [Eng.])

Gas-reversing valve. W. HEINTGES. Ger. 435,805, February 26, 1925. A valve of the Forter type, in which a cover was hinged at each end of the shell-shaped movable

portion. These covers rested in water-filled troughs between reversals, but during the operation of reversal covered the flues leading to the regenerators. (*Jour. Soc. Glass Tech.*)

Kilns, Furnaces, Fuels, and Combustion

The possibilities of the tunnel kiln for sewer pipe. W. D. RICHARDSON. *Jour. Amer. Ceram. Soc.*, **10** [9], 693–98 (1927).—The questions of whether enough sewer pipe could be set on cars and safely pushed through a tunnel kiln to make this type of kiln practicable for firing sewer pipe, and whether salt glazing would be practicable in one, are discussed. The modifications necessary in a Richardson compartment tunnel kiln to make it practicable for this purpose are enumerated and explained.

Producer gas in connection with firing fire brick. H. S. ORTH. *Jour. Amer. Ceram. Soc.*, **10** [9], 699–703 (1927).—Features in connection with firing fire brick are discussed. In tunnel kiln firing a high temperature at the charging end is essential. Desired features of producer gas firing are discussed and a producer gas-fired tunnel kiln installation is described in detail. It is shown that production capacity is dependent on the charging end temperature.

The analysis of silicate slags. T. P. COLCLOUGH. *Jour. Soc. Glass Tech.* **11** [42], 177–89 (1927).—The excess of bases in most slags tends to cause increased separation of iron, alumina, etc., in the dehydration of the silica unless special care is taken in the evaporation. Most slags are dissolved directly in hydrochloric acid. The insoluble slags are first fused with sodium peroxide. The iron alumina and phosphate are precipitated with ammonia and ammonium acetate, the manganese with bromine, and the lime and magnesia in the usual way. The lime is determined by titration of the oxalate with permanganate. Total iron is determined by solution in hydrochloric acid with a little chlorate, reduction with stannous chloride, and titration with bichromate. In the titration of ferrous iron, boric acid is added to obviate the action of the hydrofluoric acid present. Manganese is determined by the bismuthate method. The phosphorus is separated and weighed as phosphomolybdate. Methods are given for routine plant control. D.J.McS.

Manufactured city gas as an industrial fuel. G. L. MONTGOMERY. *Chem. Met. Eng.*, **34**, 404–407 (1927).—Describes the applications of gas in the plants of the Crown Cork and Seal Co., Porcelain Enamel and Mfg. Co., and Jones Holloware Co., all of Baltimore. Photographs are given but no details of equipment or operating costs. M.E.M.

Insulation of kilns. ANON. *Suddeutsche Tonind. u. Bauzeit. Rev. Mat. Constr. Trav. Pub.* [209], 35 (1927).—It is often necessary to use the waste heat from kilns for artificial drying. This heat cannot be considered as heat without cost but means a certain amount of fuel consumed. Much heat is lost by radiation from the kiln which could be saved by proper insulation. Sand and clay have been used but are very inefficient. Air is the best insulator and a porous insulation is recommended. Not only the kiln but the flue leading to the stack should be insulated to give good draft. R.J.P.

The tunnel kiln. ANON. *Tonind. u. Bauzeit. Rev. Mat. Constr. Trav. Pub.* [209], 36–37 (1927).—In 1875, O. Boch constructed a tunnel kiln having the same principles as the present day tunnel kilns but his death cut short his work and for many years the idea was forgotten. Boch's kiln was too short and used solid fuel which is not well adapted to a tunnel kiln. With the introduction of pulverized coal, oil, and gas as fuels, the tunnel kiln has made rapid progress not only in the refractory and porcelain industry but also in the heavy clay industry. A description of a new type of tunnel kiln with an illustration is given. R.J.P.

The Society of Glass Technology. ANON. *Pottery Gaz.*, **52** [602], 1279–82 (1927).—A paper on "Gaseous Fuels for Furnace Heating," by R. Wiggington, was read and discussed at the June 15th meeting of the Society of Glass Technology. See Abstract *Ceram. Abs.*, **6** [8], 357 (1927). E.J.V.

Designing of gas-fired kilns. II. ANON. *Brit. Clayworker*, **36** [423], 104–107 (1927).—Calculations are given for amount of gas required in firing gas-fired continuous fire-brick kilns of certain dimensions and output. R.A.H.

Firing hollow tile in a scove kiln. ANON. *Brick Clay Rec.*, **71** [3], 176–77 (1927).—A description of the plant and methods used at the Cohoes Brick Co., Cohoes, N. Y., which was successfully changed over from making common brick to hollow tile without changing its firing methods. Wood is used as fuel in scove kilns. E.J.V.

Practical results and experience in the drying and burning of refractory materials. FRANK WEST AND J. W. FAGAN. *Trans. Ceram. Soc.* [Eng.], **25** [4], 500–14 (1925–26).—This paper presents a selection of practical data with regard to the drying and firing of high-class silica refractories as manufactured at the Friden Works, arranged in such a way as to show the progress made. In the brickmaking industry profit is made or loss incurred in the drying and firing of the brick and molded shapes. Intelligence and skill are nowhere so surely rewarded as in the design and operation of the kilns to insure that the wares shall be subjected to the correct temperature conditions for the necessary length of time to fit them for the requirements of the user. The raw material is a silica sand containing from 88 to 97% of silica which is made up with a silica clay bond in definite proportions. The finished goods are used in the construction of the combustion chambers of gas-retort settings, the retorts themselves, and also for coke ovens. The goods are intended to withstand working temperatures ranging from 1200 to 1500°C. The stages of manufacture prior to drying and firing may be as follows: the material, after careful mixing and aging, is pugged in a wet state and pressed into the several shapes and sizes. It is then ready for drying on the steam-heated floors or in the tunnel drier. Exhaust steam is circulated from the steam engines driving the machinery of the factory. Provision is made for the addition of live steam in cold weather and live steam is also used during the night when the machinery is standing. The quantity of goods dried per 24 hrs. under this system was 3500 equivalent $9\times4\frac{1}{2}\times3$-inch bricks. Some 2 or 3 years ago, direct firing was abandoned and the Uzallete system for the use of waste heat from the kilns was installed. In this system air is drawn through those kilns which are at a sufficiently low temperature, after firing, for the cooling to be accelerated. The air picks up heat from the kilns and is then forced by means of a fan through the drier tunnel. The air is carried along the range of kilns with branches to each chamber. These branches are connected to any desired chamber by means of a collapsible tube. The temperature of the air at the inlet of the drier ranges between 200 and 300°F. The quantity of goods dried per 24 hrs. on the new system is 5,000 three-inch equivalents. The saving effected by the application of the Uzallete system to the existing drier tunnel is at least £300 per annum on fuel alone, while the kiln output has been speeded up and the drying is cleaner and easier to regulate. The two types of kilns which have proved most suitable for the purpose are the semi-continuous downdraft kilns built in benches, and the downdraft beehive kiln. The tendency in modern carbonization practice is toward higher temperatures and it is essential to fire refractories at temperatures above those at which they are to be used in order to eliminate as far as possible any expansion or contraction after the working conditions have been reached. It was found that for the last 9 years marked improvement has been brought about by better supervision and the increased use of scientific methods of operation and control. Results on firing alone, while improving the quality of the goods, show about 11% increased efficiency on the average within this period. The coal used is described as screened cobbles. It arrives

at the works in lumps varying from ½ cwt to large nuts and is broken to pass through the 4-inch diameter feeding holes. The figures show the great advantage of the continuous kilns over the beehives, the saving in fuel and labor cost completely outweighing the economy in capital cost. The question of the "soaking period" or the period of time during which the goods should be subjected to high temperatures is one of immense importance. A chart is given showing that the after-expansion is materially reduced as the soaking period is extended. R.F.S.

Electric kilns at the Gustavsberg works. A. S. W. ODELBERG. *Trans. Ceram. Soc.* [Eng.], **26** [5], 61–73 (1926–27).—In the autumn of last year, a new kiln designed and patented by the Morgan Crucible Co. and C. W. Speirs, in which 2 lines of trucks work in the same kiln but in opposite direction, was put into operation. These trucks give a surface of about 5 ft. by 1 ft., the longer truck greatly reducing the cost of working the kiln, as fewer trucks per hour are necessary for the same output. This kiln is fitted with 2 resistors and is used for glass firing cups at about 1250°C. The kiln has an overall length of about 60 ft. It has been found possible to glost-fire cups at the rate of one doz. per min., using one unit of electricity. The cost of resistors has been found in practice to be less than the cost for saggers which were necessary in the periodic coal-fired kiln, but which are unnecessary in the electric kiln. The wages are obviously much lower in the electric kiln than in the coal-fired kiln. The important feature of the kiln is that the ware is of a uniform type and little, if any, rejections are caused by the kiln. After many months' experience the rejections are below 1%. The saving under this head over the cost of rejections from a coal-fired kiln more than pays for the running costs of an electric kiln. R.F.S.

Study of the heat economy of the rotary kiln. STEHMAN. *Tonind. Ztg.*, **51** [11], 157–59, 174–77 (1927). F.P.H.

Short or long drying time. GEORG ZEHNER. *Tonind. Ztg.*, **51** [11], 162–63 (1927).—A description of the advantages and disadvantages of the short drying time for ceramic ware. F.P.H.

The changes that have taken place in the design of the Hofmann ring furnace. A. HIELSCHER. *Tonind. Ztg.*, **51** [15], 225–28; **51** [16], 242–45 (1927). F.P.H.

Radiation from luminous flames. R. T. HASLAM AND M. W. BOYER. *Fuels and Fur.*, **5** [8], 1049–50 (1927).—While it has generally been known that a luminous flame radiates more heat than a nonluminous flame, very little experimental work has been carried out to determine the difference quantitatively. The methods by which this quantity was measured are described in detail and a table showing the data obtained is given. The radiation from a truly luminous flame is from 25 to 30% of the total heat of combustion of the gas and is about four times that from a nonluminous flame. The least saturated gases give the greatest radiation. The results support the suggestion of Lent that nonluminous flames be inoculated with an illuminating material. This is an abstract of a paper presented before the Philadelphia meeting of the American Chemical Society. A.E.R.W.

Natural sources of energy in Australia. J. READ. *Chem. and Ind.*, **46**, 613–15 (1927).—Natural petroleum, power alcohol (from Queensland molasses and arrow-root), coal, kerosene shale, brown coal and its carbonization, hydroelectric power, and solar energy are reviewed in turn. H.H.S.

Cleaning of coal, with special reference to pneumatic separation. C. W. H. HOLMES. *Jour. Soc. Chem. Ind.*, **46 T**, 270–79 (1927).—According to present theory, it should only be possible to separate ½-inch particles of shale from ¾-inch particles of coal by a pneumatic process, but as a matter of practice separations of high efficiency can be made on a 4 : 1 size ratio. H. is of the opinion that a modification of Henry's rudder law is more applicable to pneumatic separation than the theory founded on hydraulic classification,

The air-separators of the types "S. J.," "Wye," and "Half Wye" were used, with Tyler standard screens and Tyler Ro-Tap machine for laboratory sizing. The products of the Half Wye were: clean coal 60.65%, middlings 14.65%, refuse 24.7%. H.H.S.

Flame temperature of producer gas using preheated air and gas. ROBERT NITZSCHMANN. *Chem. Ztg.*, **51,** 197–98 (1927).—Detailed formulas, and a number of curves, are given for the determination of flame temperature of producer gas burned with O_2–N_2 mixtures ranging from air up to 100% O_2, for various conditions of preheating. (*C. A.*)

Combustion velocity and equilibria in combustion. W. ALLNER. *Z. Ver. deut. Ing.*, **71,** 411–18 (1927).—A general discussion and summary of data on the various factors entering into gaseous combustion, and of their application to practice. (*C. A.*)

The heat-capacity-temperature diagram of combustion, and the efficiency of furnaces. P. ROSIN. *Z. Ver. deut. Ing.*, **71,** 383–88 (1927).—Just as thermal efficiencies of heat engines are calculated from the data of thermodynamics, so must those of furnaces be computed, for they are in reality only heat engines. With heat capacity represented as ordinates and temperatures as abscissas, data for the combustion of various fuels, heat content of flue gases from the above, preheating effects, etc., are shown in graphs and tables, and then applied in diagrams giving results from burning coal, lignite, producer gas, and other fuels. (*C. A.*)

Laboratory electric furnace for temperatures up to 1400°. S. REINER. *Chem. Ztg.*, **50,** 578 (1926).—A simple furnace formed by placing suitably shaped blocks of refractory material about an Fe or quartz tube is described. (*C. A.*)

Pulverized fuels. W. LULOFS. *Chal. et Ind.*, **7,** 177 (1926).—The following data in connection with the combustion of pulverized fuel were evaluated: (1) the weight of spent gas per kg of combustible, (2) the theoretical temperature of combustion with varying proportions of air. Curves showing the relationships between the above values, the percentage of carbon dioxide in the waste gas, and the ratio of air used to that theoretically needed in the case of 2 coals of varying composition were also given. The troubles due to the rapid liberation of large quantities of heat in the combustion chamber, when pulverized fuel was employed, were discussed. (*Jour. Soc. Glass Tech.*)

Graphic method for the determination of the calorific power of coal. A. DE ZAWARITZKY. *Chal. et Ind.*, **7,** 191 (1926).—Values of calorific power of coals of varying composition were calculated by Goutal's formula, and the results expressed in the form of 8 sets of graphs, enabling values to be read directly to within 0.5 to 3%. (*Jour. Soc. Glass Tech.*)

The optimum content of carbon dioxide in spent gas. A. GREBEL. *Chal. et Ind.*, **7,** 307, 389 (1926).—There was an optimum percentage of carbon dioxide in spent furnace gas (since it was necessary to use excess air to promote complete combustion), but this value depended on several factors, such as the fuel used, the type of grate, the rate of combustion, etc. G. discussed the individual points to be considered in determining this optimum value. (*Jour. Soc. Glass Tech.*)

High temperature measurements of gas in industry. H. GUILLON. *Chal. et Ind.*, **7,** 395, 472 (1926).—It was difficult to measure with exactitude the temperature of a flowing gas. The trouble most difficult to eliminate was radiation on the walls. As a solution of the problem, a pyrometer was designed in which the element was inclosed in a tube in which the gas was caused to circulate at such a rate that temperature equilibrium between walls and gas was assured. (*Jour. Soc. Glass Tech.*)

The utilization of solid fuels in small automatic fires up to the fusion point of the ash. M. DE CONNICK. *Chal. et Ind.*, **7,** 443 (1926).—A small furnace suitable for several uses and automatic in action was attained by using pulverized coal. No grate was required, the fuel being injected from below, the air entering from above and in its downward

course burning the fuel without the base attaining excessive temperatures. The ash ran continuously into a cooled receptacle concentric with the orifice of injection. By this means, a thin layer of solid ash was formed while the liquid ash, collecting above, flowed away. (*Jour. Soc. Glass Tech.*)

Utilization of waste heat from ceramic kilns. ANON. *Keramos*, **5**, 457 (1926).—A waste heat plant is described, by means of which superheated steam is produced from the waste heat of kilns both at the firing and the cooling periods. A number of periodic kilns are essential to the economic working of the system. The kilns are connected by a collecting flue, which conducts the hot gases to a boiler at a temperature of about 400°. (*Trans. Ceram. Soc.* [Eng.])

Tests on a modern regenerator at the A. G. Charlotte works in Niederschelden on the Sieg. P. KÜHN, O. BECKMANN, W. FRANZEN, G. NEUMANN, AND A. SCHACK. *Stahl u. Eisen*, **46**, 801 (1926).—The temperature conditions inside a regenerator or a Martin furnace have hitherto not been investigated. Advantage was therefore taken of a period of reconstruction to conduct careful tests on a regenerator having an exterior diameter of 6.520 m, and a total height of 23.400 m, the height of the checker work being 17.8 m. The checker bricks were 50 mm thick and were built up into square columns, 100 by 100 mm in cross-section. The greater part of the regenerator was insulated with bricks 50 mm thick. A number of platforms was constructed at varying heights, so that temperature measuring instruments could be fitted and observed. The object of the work was to determine (1) the efficiency of the regenerator; (2) the distribution of the hot gas in the checker work; (3) the temperature of the bricks, air, and gas; (4) the fall in temperature per meter of checker work; (5) the heat movement in the checker work. The total distribution of heat in the regenerator is given in a table:

Total losses	31.9%
Sum of useful heat	65.6
	97.5
Not accounted for	2.5
	100.0

The results show that the checker work in the regenerator under investigation was used to the full extent only in the upper third, the lower two-thirds being utilized less and less as the temperature of the waste gas falls. Consequently, the method hitherto adopted of building the checkers into columns of equal cross-section throughout is thermotechnically wrong. It would be advisable to construct the upper third of the regenerator with square or, better, rectangular columns as hitherto; the middle third with columns of smaller cross section built of thinner bricks, thus giving a greater surface; and in the bottom third the cross-section of the columns and the thickness of the bricks would be still further reduced. By such an arrangement, better use would be made of the waste gases and of the checker work and the regenerators could be considerably lower. (*Trans. Ceram. Soc.* [Eng.])

Ceramics and firing technique. G. KOPKA. *Zpravy Ceskoslov. Keram. Spol.*, **1**, 24 (1924).—The consumption of fuel is relatively greatest in the porcelain industry. The amount of coal of 11,700 B.t.u. required to produce 100 kg of steam = 29 kg; building bricks, 10 kg; grog bricks, 21 kg; cement, 33 kg; steel, 30 kg; pig iron, 130 kg; glass, 120 kg; porcelain, 300 kg. Economic firing requires the admission of the right quantity or air; thorough mixing of fuel and air; attainment of the ignition temperature (350°–800°) of the gases in the fire box. Heat losses through excess air, expressed as percentages of the calculated value of the coal, are:

Excess air	Heat losses with a flue gas temperature of 100° %	500° %
1-fold	0.7	13.0
2-fold	8.0	40.0
3-fold	22.0	over 70.0
10-fold	60.0	—

Losses by incomplete combustion are:

Air	CO-content of flue gas %	Heat loss %
1-fold	0	0
0.8-fold	10	30
0.7-fold	18	46
0.6-fold	27	65

Directions are given regarding the correct construction of furnaces, etc., choice of most suitable fuel, and method of conducting firing operations. (*Trans. Ceram. Soc.* [Eng.])

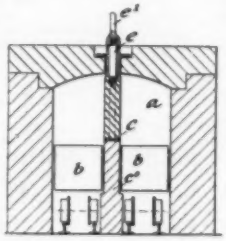
Recent work on firing ceramic kilns. G. KOPKA. *Zpravy. Ceskoslov. Keram. Spol.*, **1**, 78 (1924).—Recent work in France, Germany, and Czechoslovakia, by Granger, Bodin, Block, Keppeler, Rieke, etc., is reviewed. (*Trans. Ceram. Soc.* [Eng.])

BOOK

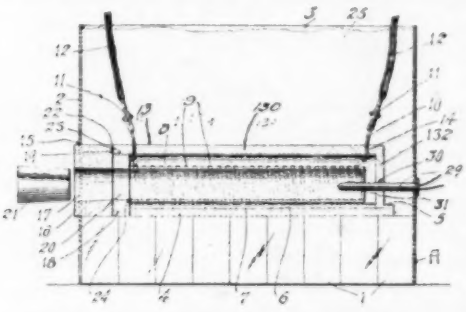
Fuel Combustion. D. AUFHAUSER. Berlin; Julius Springer (1926). 116 pp. bound 4.2M. *Tonind. Ztg.*, **51** [33], 574 (1927). F.P.H.

PATENTS

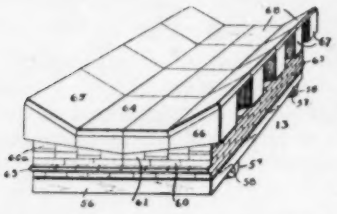
Kiln and other heat-treatment furnace. CHARLES WILLIAM SPEIRS. U. S. 1,630,587, May 31, 1927. A tunnel kiln wherein the firing zone is formed by an electric resistor fixed vertically in the center of the tunnel so that the heat is radiated equally from both sides on to two streams of articles passing either in the same or opposite directions.



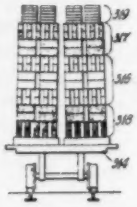
Muffle furnace. EDWARD A. COLBY, FREDERICK MAEULEN, AND GEORGE L. VAN ALLEN. U. S. 1,631,474, June 7, 1927. In a muffle furnace, the combination of a casing to receive a muffle and having an opening at its top to receive granular heat insulating material and an opening in one side, a muffle housing including a base having an end wall formed with a charging opening accessible through said side opening of the casing, a closure for said charging opening, and a muffle cover having an open bottom with its edges removably resting upon said base and one end open the edges of which separably abut said end wall of said base, a muffle removably mounted upon said base and having one open end the edges of which abut said end wall of said base around said charging opening, the top, sides and other end of said muffle being in spaced relation to said cover to form a closed air heat insulating space between the muffle and said cover, an electric heating coil surrounding said muffle, and granular heat insulating material in said casing surrounding said muffle housing, said muffle housing protecting said muffle against the weight of said granular insulating material.



Kiln truck. HARRY M. ROBERTSON. U. S. 1,636,073, July 19, 1927. A truck for use in apparatus having a heated chamber comprising a wheel mounted frame, a base portion on said frame, supporting refractory blocks on said base portion, the engaging faces between said base portion and said blocks being complementary and co-acting to prevent outward movement of said blocks, and refractory walls resting on said blocks and arranged to form a holder for material.

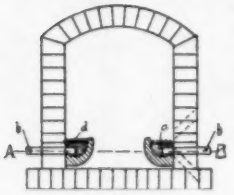


Process of firing ceramic products. WILLIAM LEE HANLEY, JR. U. S. 1,636,417, July 19, 1927. The herein described process of firing brick, which consists in supporting a plurality of layers of brick, placing in the lower layers bricks requiring relatively lower temperature to fire them and bring them into commercial condition, and placing in the superposed layers brick requiring a higher temperature to fire them and bring them into commercial condition, and subjecting said layers, in an inclosing chamber, to heat sufficient to properly fire the brick of the lower layers, whereby the bricks of the upper layers will be subjected to a higher temperature and economy of fuel is attained.

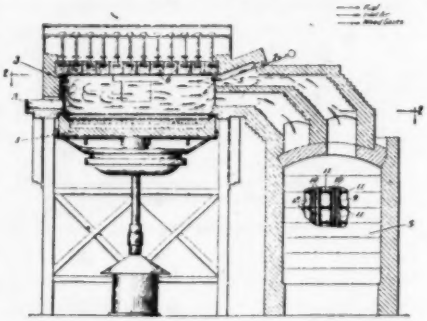


Oven. REGNIER EICKWORTH. U. S. 1,636,989, July 26, 1927. In an annealing oven a movable partition composed of a plurality of blocks of refractory material connected to form a flexible curtain and rotary means for winding and unwinding such curtain.

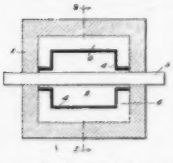
Electrical heating body for high temperatures especially for ceramic metallurgical processes and chemical processes. FERDINAND WECKERLE. U. S. 1,637,167, July 26, 1927. In an electric furnace, an open gutter for receiving a heating body of silicate adapted to be reduced by heat to a liquid conductor, and taps communicating with said gutter and extending into said liquid body to permit of the volume thereof being changed at will to vary its resistance.



Furnace and method of operating the same. ALBERT L. CULBERTSON. U. S. 1,637,473, August 2, 1927. A furnace having a hearth, a heating chamber disposed above said hearth, means for moving the hearth relative to the chamber, and inlet and outlet ports for heating gases located at different levels on one side of said chamber to cause the gases to pass across the hearth at one level, turn, and then pass back across the hearth at another level before leaving the chamber.



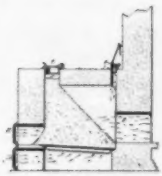
Electric furnace. JAMES KELLEHER. U. S. 1,637,486, August 2, 1927. An electric furnace comprising end and side walls of refractory silicon material enclosing a chamber, a carbonaceous resistor extending through said chamber from end to end, an inner lining of carbonaceous material surrounding said resistor and forming a chamber therefor, and a packing between the inner



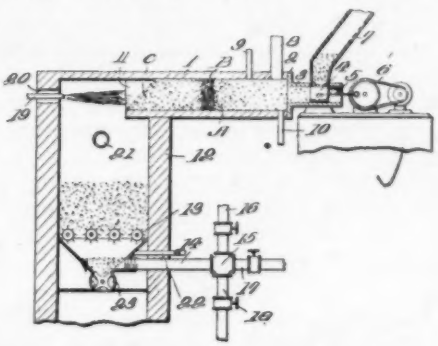
lining and the outer wall of sufficient thickness to avoid entrance of silicon vapor from said walls into said resistor chamber.

Reciprocating car kiln. PHILIP D'HUC DRESSLER. U. S. 1,638,988, August 16, 1927. In a kiln the combination with a kiln chamber having 2 spaced apart ports for the inlet and egress of ware, of a ware support movable back and forth in said kiln chamber to permit wares loaded on said support through either port to be removed through the other port.

Process and apparatus for firing clay products. JOSEPH ASHBY REAMS. U. S. 1,639,271, August 16, 1927. A kiln furnace of the type having a fuel-grate, a shovel-stoking-door, and a rear flame-exit leading to the kiln, the top wall of said furnace being provided with a fuel-charging passage, this passage having a closure device adapted to be opened or closed, said fuel-charging passage being located adjacent the front wall of the furnace, a supplemental air-supply passage being provided at the rear of the furnace positioned to deliver air into the combustion-chamber at the inlet of the flame passage, this supplemental air-passage being provided with an adjustable closure device.



Carbonizing apparatus. GEORGE W. WALLACE. U. S. 1,639,390, August 16, 1927. In a carbonizing apparatus, a short and wide, substantially horizontal reaction chamber in the form of a conduit, stoker means for supplying fresh material at one end and advancing the same therethrough as a charge filling the entire cross-section of said conduit, means for removing gases and vapors at the same end and localized heating means for impinging hot gases against a charge in the chamber at the other end, such localized heating means being adapted to permit the establishment and maintenance of a substantially stationary carbonizing zone at one point in said reaction chamber.

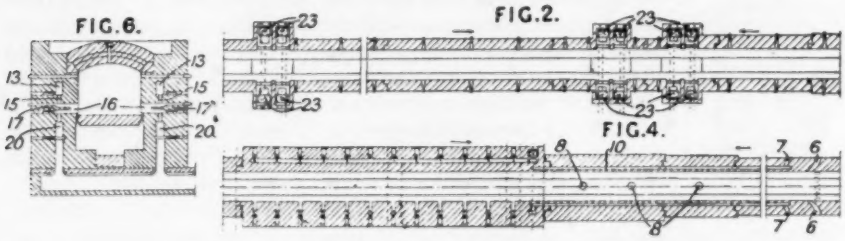


Process of distilling and gasifying solid carbonaceous fuel. GEORGE W. WALLACE. U. S. 1,639,391, August 16, 1927. In the low temperature distillation and carbonization and gasification of solid fuel containing volatile matter, the process which comprises establishing and maintaining a substantially horizontal moving column of material to be carbonized, impinging a flame of burning gases on one end of said column, passing said burning gases through the material in countercurrent, maintaining the opposite end relatively cool, whereby an intermediate stationary zone of carbonization is established and maintained at a self-regulating temperature, and gasifying the hot materials coming from the end against which the flame gases are directed by passing a draft current through the materials to effect such gasification.

Method of carbonizing fuel. GEORGE W. WALLACE. U. S. 1,639,417, August 16, 1927. In the production of coke or smokeless fuel and by-products by carbonization the process which comprises establishing and maintaining a moving substantially horizontal pervious column of fragmentary solid carbonizable material in a chamber of

conduit form as a full area charge, one end of said column being formed by incoming relatively cool material, impinging a flame on the other end of said column and transmitting hot flame gases through said column in a direction counter to the passage of solid materials, whereby a stationary zone of carbonization is established and maintained.

Tunnel Kilns. COMPAGNIE GENERALE DE CONSTRUCTION DE FOURS. Brit. 272,238, August 4, 1927. In a tunnel kiln, which is so constructed that the temperature and the atmosphere prevailing at various points of the tunnel can be controlled, the air supply for the fuel burners is heated in flues in the wall of the cooling-zone. In the kiln shown in sectional plan in Figs. 2 and 4 (which should be joined), air is supplied under pressure through ports (6, 7), the former opening into the tunnel and the latter into flues (10) in the walls of the cooling-zone. By drawing off heated air through roof ports (8) the temperature gradient in the cooling-zone can be varied as desired. The air from the flues (10) is passed under control of a damper to flues (13), Fig. 6, running the length of the firing-



zone, and from these through damper-controlled ports (15) to the burner ports (16). Gas is similarly supplied from longitudinal flues (20). In each burner port (16) the gas and air ports are separated by a tapering tongue (17). Solid fuel may be used in addition to gas, and in this case, and also when the materials under treatment give off combustible gases, air alone may be supplied through some of the burner ports, or from other sources, *e.g.*, through ports in the trucks. The waste gases are drawn off through flues (23) distributed along the preheating zone, and by varying the proportion of gases drawn off at the different exits the temperature gradient may be varied. The goods to be fired is either built up directly on the trucks or placed in large saggers, which may have air ducts in their walls.

Geology

Ceramic properties of some white burning clays of the eastern United States. ANON. Bur. Stand., *Circ.*, No. 325, (1927).—This paper contains a rather thorough study of certain of the qualities of a large number of white-firing clays from the U. S. This study was made with a view to determining the possible domestic sources of clays of the character which are so largely imported for the pottery trade. Seventy-seven representative samples of white clays were gathered and for each sample there is given: (1) a brief account of the nature of the deposit; (2) the results of an elutriation of the clay by water; (3) a microscopic determination of the mineralogical composition of each fraction obtained by elutriation; (4) the molding properties, workability, color, per cent tempering water, and volume shrinkage on drying of the clay; (5) certain of the firing properties of the clay; (6) certain of the properties of a porcelain containing this clay. Abstract of this paper appears in *Ceram. Ind.*, **9** [2], 141 (1927). R.A.H.

On some pottery china clays and the granite from which they are derived. J. M. COON AND E. J. LEWIS. *Trans. Ceram. Soc.* [Eng.], **25** [4], 490–96 (1925–26).—That china clay, as found in Devon and Cornwall, is a result of a kaolinic alteration of feldspar

in a previously existing granite rock, is assumed. The granite of the area may be described as holocrystalline, medium grained, containing quartz, alkali feldspars in which the soda series is dominant, ferro-magnesian minerals inconspicuous and light in color, fluorine-bearing minerals characteristic and relatively plentiful. Proceeding from the surface downward a zone is first reached in which disintegration is dominant with scarcely noticeable mineral metamorphosis. Then follows a zone of varying depth representing, at that place, the annual and secular variation of the underground hydrostatic level, in which greisenising is much in evidence along with kaolinization. This zone is frequently oxidized by the access of air and waters bearing iron, probably derived from vegetable decomposition and possibly also by water infiltrating from one level to another. Under this is the region of more complete kaolinization, from which the whiter and desirable china clay is recovered. Associated with the china clay rock are found portions of the granite in which the alteration is only partial or incipient, and these afford opportunity for comparative study with the china clay. The localities of the granites and clays selected for this paper form part of the Western St. Stephen-in-Brannel District, which is not more precisely identified that frank descriptions may be given. It is believed that an increased used of the microscope at the producing end would greatly assist in the elimination of undesirable matters and at the using end, in a better understanding and adaptation of china clays to the arts and manufactures. R.F.S.

The Japanese acid clay. NAOTO KAMEYAMA. *Jour. Soc. Chem., Ind., Japan*, **30** [6], 103–104B (1927).—Japanese acid clay has properties analagous to those of fullers' earth in England and Florida earth in the United States. It is generally believed in Japan, however, that its adsorptive and decolorizing powers are superior to those of fullers' earth and Florida earth. The clay is said to have a composition represented by Al_2O_3, $6SiO_2$, xH_2O, x being greater than 6, and is the decomposition product of quartz porphyry. The clay absorbs caustic alkali from its aqueous solution, to which it owes its name. The strong adsorptive and decolorizing properties are utilized now extensively in the refining of mineral and fatty oils. The properly dried clay has a strong dehydrating action, which is manifested by the fact that ethyl alcohol forms ether, when the vapor is passed through the dried clay kept at about 250°C. A new aspect upon the property of the acid clay is given by the discovery of the presence of an appreciable quantity of rare earths in the acid clay. These include Ce, Nd, Pr, Y, Er, Dy, Tm. E.J.V.

South African china clay. ANON. *Pottery Gaz.*, **52** [602], 1275 (1927).—Deposits of china clay have been found in several localities in the Union of South Africa. Samples showed contamination of quartz sand which would have to be removed. Comparative trials of washing were made on the South African raw clay and Cornish china clay rock, using a water current speed such as had been found necessary to remove the fine clay from the English raw material. Under these conditions the South African clay left 8% of residue, while the Cornish rock yielded about 57%. The washed clay yielded by the South African material had the same appearance as the refined Cornish china clay, but contained more grit which is detrimental to its use as a high grade filler. Tests were made using the clays in earthenware and china bodies, replacing the one clay with the other. A comparison of the drying and firing shrinkages of the raw clays and earthenware mixtures using each was made with the following results:

	Drying shrinkage %	Additional shrinkage in firing %	Total shrinkage %
South African clay	3.8	7.5	11.3
English kaolin	1.9	5.6	7.5
South African earthenware	3.8	8.1	11.9
English earthenware	3.1	7.5	10.6

Bone China produced from South African china clay by firing at about 1250°C and covering with a feldspathic glaze was similar in appearance to that made with English kaolin. E.J.V.

Potash from Palestine. ANON. *Chem. and Ind.*, **46**, 659–60 (1927).—Since the British Empire hitherto has found no substantial source of potash salts, the immense deposits of the Dead Sea are claiming attention. The Colonial Office Committee estimates them at 2 billion T of potash, and suggests an annual production of 100,000 T per annum. The overall cost on board ship at Jaffa is under $20.00 per T. A concession has been granted. H.H.S.

The rock products in Texas. EDMUND SHAW. *Rock Prod.*, **30** [15], 56–58 (1927). F.P.H.

The Hungarian bauxite industry. ANON. *Rock Prod.*, **30** [16], 56 (1927). F.P.H.

The production of quartz dust and quartz sand. W. SCHUEN. *Tonind. Ztg.*, **51** [20], 309–11 (1927).—A description of the mining and production of Frechener flint and sand is given. The chemical analysis of this material covering a period of 10 years is given and shows remarkable uniformity. The sieve analysis for the various grades of flint is given. F.P.H.

Valuation of clay and loam deposits. OSTMAN. *Tonind. Ztg.*, **51** [21], 521–22 (1927). F.P.H.

Hydrothermal alteration of certain silicate minerals. R. J. LEONARD. *Econ. Geol.*, **22**, 18 (1927).—The effect of different solutions at various temperatures and pressures upon certain feldspars and spodumene was studied. The X-ray method, in addition to the usual methods, microscopic, blowpipe, chemical analysis, was used in studying and identifying the substances recovered. Feldspars and spodumene were not altered by alkali carbonate, chloride, and sulphate solutions at 100°. Hydrochloric acid partially decomposed labradorite, producing a small percentage of residual silica. Sulphuric acid did not attack microcline or albite, but almost completely decomposed labradorite and bytownite, leaving only silica as decomposition product. Alunite was produced from feldspars at 22°, 65°, and 100° at atmospheric pressure, and at 200° and 15 atmospheres by the addition of aluminium sulphate to sulphuric acid, potassium sulphate and sodium sulphate solutions, and by aluminium sulphate solution alone. A substance formed synthetically from mixtures of aluminium sulphate and alkali sulphate solutions was found by analysis and X-ray diffraction patterns to be alunite. Hydrochloric and sulphuric acid reactions at 200° and a pressure a little below 15 atmospheres gave partial or complete solution of feldspar. Similarly, zeolites, cryolite, and products closely resembling leverrierite and sericite were obtained. X-ray patterns are shown, and analyses of fresh and altered minerals are given. Kaolin was not produced in any of the experiments. (*Trans. Ceram. Soc.* [Eng.])

Chemistry and Physics

The quantitative microscopic analysis of commercial feldspar. HERBERT INSLEY. *Jour. Amer. Ceram. Soc.*, **10** [9], 651–69 (1927).—This investigation was undertaken to develop microscopic methods for determining quantitatively the mineral constituents in feldspars used in the ceramic and allied industries. After several methods had been tried, a method of counting the grains and of using liquids of different indices of refraction for distinguishing the constituents was finally adopted. Nineteen commercial feldspars were analyzed by this method and the results compared with the results obtained by computing the chemical analyses to mineral constituents. Another method in which a partially fused sample was examined microscopically was also found suitable. It is concluded that, while neither the counting method nor the fusion method is as

accurate as chemical analysis, the counting method gives satisfactory results for plant control in terms of potash feldspar, plagioclase feldspar, and quartz when used by a skilled microscopist, and the fusion method gives satisfactory results in the hands of the plant technologist for estimating quartz.

Measurement of plasticity. T. W. TALWALKER AND C. W. PARMELEE. *Jour. Amer. Ceram. Soc.*, **10** [9], 670–85 (1927).—The object of this investigation was to devise a rational method and primary standard for measuring plasticity. Various methods suggested in the past were critically examined and found wanting. An apparatus was developed to measure the stress-strain relations of clays in shear and a few typical clays have been examined by this method. A definition is proposed for the unit of plasticity as follows:

$$\text{Index of plasticity} = \frac{\text{Total deformation at fracture in shear}}{\text{Average stress beyond proportional limit}}$$

The effect of addition of sand and powdered graphite has been noted and throws some light on the nature of plastic deformation.

Thioglycolic acid as a color test for iron. EDWARD LYONS. *Jour. Amer. Chem. Soc.*, **49** [8], 1916–20 (1927).—Thioglycolic acid is recommended as a delicate test for iron. It is capable of detecting iron in dilutions up to 1:10,000,000 and is relatively much more delicate than the usual thiocyanate test. The test is independent of the state of oxidation of the iron since it is given equally well with either ferrous or ferric iron. The test is capable of quantitative application and when used in conjunction with thiocyanate test gives a simple method for estimating both ferric and ferrous iron in the same solution by colorimetric methods. R.J.P.

Industrial chemistry in Japan, research institutions, and scientific societies. NAOTO KAMEYAMA. *Jour. Soc. Chem. Ind., Japan*, **30** [1], 1–3B (1927).—The Imperial Universities of Tokyo, Kyoto, Kyushu and Tohoku, and the Waseda University have Departments of Applied Chemistry. Research organizations in Japan include the Research Institute for Iron, Steel, and Other Metals, of the Tohoku Imperial University, the Aeronautical Research Institute of the Tokyo Imperial University, Tokyo Imperial Industrial Laboratory, Osaka Imperial Industrial Laboratory, the Nitrogen Research Laboratory, the Laboratory for Pottery in Kyoto, and the Institute of Physical and Chemical research. The scientific societies include the Chemical Society of Japan, the Society of Chemical Industry, the Japanese Ceramic Association, the Fuel Society, the Society of Agricultural Chemistry, and "Cellulose Institute." E.J.V.

Caustification of sodium carbonate by ferric oxide. (6th report.) The heat of formation of sodium ferrite. (Experiment I). MOTOTARO MATSUI AND TOMONOSUKE SAKAMAKI. *Jour. Soc. Chem. Ind., Japan*, **30** [1], 9–13B (1927).—The heat of solution of the ignited product of a mixture of 1 mol Na_2CO_3 and 1.2 mol Fe_2O_3 in hydrochloric acid was measured in an electrical calorimeter and the heat of formation of sodium ferrite was calculated therefrom. Sources of experimental error are discussed. New thermochemical equations expressed are:

$$Na_2O(s) + Fe_2O_3(s) = Na_2Fe_2O_4(s) + 44{,}820$$
$$Na_2CO_3(s) + Fe_2O_3(s) = Na_2Fe_2O_4(s) + CO_2(g) - 32{,}060$$
$$2NaO(s) + 2Fe(s) + 2O_2(g) = Na_2Fe_2O_4(s) + 248{,}080$$
$$Na_2Fe_2O_4(s) + H_2O(1) = 2NaOH(aq) + Fe_2O_3(s) - 101{,}320$$

The specific heat of Na_2CO_3 was measured, giving a mean value of 0.27655 calories, which was fairly concordant to Regnault's figure of 0.273 calories. E.J.V.

Achievement in the manufacture of soda ash. NAOTO KAMEYAMA. *Jour. Soc. Chem. Ind., Japan*, **30** [2], 25–26B (1927).—The only producer of soda ash in Japan is the Asahi Glass Co., which after 10 years of work on the problem is now able to supply

soda ash by the ammonia soda process with a small margin of profit. Its daily production was 10 T in 1917, 20 T in 1919, 30 T in 1922, 30 T in 1925, and now is 60 T. In 1921 a ton of soda ash produced required a consumption of 1.9 T salt (85% purity) and 14 kg of ammonia, the figure now having decreased to 1.78 T and 9 kg respectively. The chief difficulty lies in the high cost and poor quality of the salt. E.J.V.

Caustification of sodium carbonate by ferric oxide. (7th report.) Dissociation pressure of Na_2CO_3 in the presence of Fe_2O_3. (Experiment II). MOTOTARO MATSUI AND KAZUO HAYASHI. *Jour. Soc. Chem. Ind., Japan*, **30** [2], 28–33B (1927).—A detailed description of the apparatus and methods used is given. Data obtained is given in tabular form. From the results obtained the isochore expression, $\log p = \frac{-7539.6}{T} + 1.75 \log T - 0.001626T + 6.0808$, was deduced and the heat content, Q, on the thermochemical equation, $Na_2Fe_2O_4(s) + CO_2(g) = Na_2CO_3(s) + Fe_2O_3(s) + Q$, was computed as 34,880 calories. E.J.V.

Caustification of sodium carbonate by ferric oxide (8th report.) The thermal dissociation of sodium carbonate in the presence of ferric oxide and some empirical dissociation pressure equations. MOTOTARO MATSUI. *Jour. Soc. Chem. Ind., Japan*, **30** [3], 47–52B (1927).—The molecular heat of $Na_2Fe_2O_4$ calculated according to Nernst's heat theorem is 34,883 and 34,778 calories, and ΔCp is -0.9 and -0.96, respectively. According to Cederberg's expression for heterogeneous equilibrium $Q_{295.6}$ becomes 34,600 calories and ΔCp is -1.28. Expressions solving by the use of the reaction heats at room temperature and at higher temperatures, including the integrated Clausius-Clapeyron equation, G. N. Lewis' expressions and Henglein's expressions, are compared. E.J.V.

Caustification of sodium carbonate by ferric oxide (9th report). Supplemental calculations on the thermal dissociation of Na_2CO_3 in the presence of Fe_2O_3. MOTOTARO MATSUI. *Jour. Soc. Chem. Ind., Japan*, **30** [5], 91–93B (1927).—The equations and results of supplemental calculations are given. E.J.V.

Physico-chemical properties of acid clay. I. On the ultramicroscopic observation of acid clay. KYUHEI KOBAYASHI AND KEN-ICHI YAMAMOTO. *Jour. Soc. Chem. Ind., Japan*, **30,** [7], 119B (1927).—Ultramicroscopic photographs of several acid clays, colloidal carbons, silica gels, etc., have been taken by Cardioid ultramicroscope and the sizes of the particles have been determined by use of the Slit ultramicroscope. The colloidal structure of the acid clay was observed and some differences were shown to exist between acid clay and many other clays. It has been considered that the acid clay is constituted of very minute particles comparing with other clays and the radius of the particles which remains in the solution separated by the centrifugal machine at 4000 r.p.m. has been calculated to be between 1×10^{-5} and 2×10^{-5}. Acid clay which has been calcined at 300°C shows no perceptible change of structure, but at 500°C its colloidal structure has disappeared, changing into a transparent rocky appearance. E.J.V.

On the behavior of kaolinite at high temperatures. WOLD ISKULL. *Ber. des. keram. Forschungsinstituts*, Leningrad, Vol. 2 (1925); *Tonind. Ztg.*, **51** [32], 559 (1927). F.P.H.

The clay colloids of soils. A. DEMOLON. *Chimie et Ind.*, **16** [4], 552–55 (1926); *Tonind. Ztg.*, **51** [32], 559 (1927). F.P.H.

Alkaline treatment of leucite for potash. F. JOURDAN. *Rock Products*, **30** [16], 75 (1926).—An abstract of a recent article by J. in *Chaleur et Industrie*. For patent by J. see *Ceram. Abs.*, **6** [5], 194 (1927). F.P.H.

Simple method for the determination of the specific gravity of brick. EBERHARD KUHN. *Tonind. Ztg.*, **51** [6], 70–71 (1927).—A description of a simple gas porosimeter. F.P.H.

The chemist in the ceramic industry. H. KOHL. *Tonind. Ztg.*, **51** [6], 69–70 (1927). F.P.H.

Concerning the plasticity of clay. GUSTAV KEPPELER. *Tonind. Ztg.*, **51** [8], 105–107 (1927). F.P.H.

Cement, blast furnace slag, and minerals. W. SCHOERK. *Tonind. Ztg.*, **51** [28], 462–63 (1927).—A presentation of structural formulas for minerals, slags, and cements is given. F.P.H.

Production of sulphurous acid from gypsum. B. NEUMANN. *Zeits. angew. Chem.*, **39,** 1542 (1926); *Tonind. Ztg.*, **51** [15], 234 (1927). F.P.H.

The decomposition of bauxite with caustic soda without pressure. BERNH. NEUMANN AND O. REINSCH. *Zeits. angew. Chem.*, **36,** 1545 (1926); *Tonind. Ztg.*, **51** [9], 129 (1927). F.P.H.

Organic derivatives of silicon. Pt. 32. The carbon-silicon binding. F. S. KIPPING. *Jour. Chem. Soc.*, p. 104 (1927).—Evidence is given to show that an ethylenic binding between carbon and silicon is either impossible or can only be produced under exceptional conditions. (*Trans. Ceram. Soc.* [Eng.])

The use of glass electrodes. P. M. T. KERRIDGE. *J. Sci. Instr.*, **3,** 404 (1926).—Glass electrodes or glass cells were used for the measurement of the hydrogen-ion concentration of solutions. The method depended on the fact that, if a thin glass membrane be allowed to separate 2 solutions of different hydrogen concentrations, a difference of potential exists between the 2 sides of the glass. The membranes used were as thin as possible (about 0.025 to 0.030 mm) consistent with their being able to support water. They were blown in the form of a thin bulb at the end of a glass tube or as a bulb inside another larger and thicker bulb. Contact with solutions in the glass electrodes was made by means of 2 calomel electrodes, and the potential difference was measured by an electrometric method. Many types of glasses were found to be suitable for the work. A soft soda-glass of low durability was frequently used, but glasses rich in borosilicates were unsuitable. Before a new glass electrode was used, it required to be thoroughly cleaned. If chromic acid was used for this purpose, it was necessary to soak the electrode in water for 2 days before use, as there was a potential at the glass surface, due to the absorption of the acid, which rapidly diminished during the period of soaking. (*Jour. Soc. Glass Tech.*)

Studies on the volatilization of cryolite. A. OTREMBA. *Keram. Rund.*, **34,** 375, 397, 411, 432 (1926).—Cryolite, together with the more common glass-making materials, taken singly and then in various combinations, was heated in a platinum crucible placed in a gas furnace and the volatilization at different temperatures from 600 to 1000° determined. As the amount of fluorine that volatilized increased, the turbidity of the glasses diminished. The turbidity obtained by cryolite was very intense, and it was possible for it to remain stable at high temperatures. The fluorine combined with another element, and the compound first took a crystalline form, but was decomposed at higher temperatures, giving gaseous fluorine. After the formation of the gas, a further crystallization point was reached, whereby extremely small crystals, only recognizable as black points, were precipitated. Increase of the soda content tended to change the color from white to yellow and then to gray. Cryolite itself tended to change the color to yellow. The turbidity obtained with artificial cryolite was more intense and of purer color than that obtained with the natural product. Cryolite acted as a flux when added to enamels. The greatest fluxing effect when cryolite was added to a mixture of equal quantities of quartz and feldspar occurred when the cryolite amounted to 20% of the total. (*Jour. Soc. Glass Tech.*)

Crystallized bubbles. ANON. *Sprechsaal*, **59,** 581 (1926).—A discussion on the formation of crystalline inclusions in bubbles. (*Jour. Soc. Glass Tech.*)

Chemical reactions in mixtures of solids at high temperatures. G. TAMMANN. *Z. angew. Chem.*, **39**, 869 (1926).—The temperature of the beginning of internal diffusion was of fundamental importance for all reactions in the solid state. T. discussed methods by which this point could be determined. (*Jour. Soc. Glass Tech.*)

Thermal dissociation of fluosilicates. G. HANTKE. *Z. angew. Chem.*, **39**, 1065 (1926).—The dissociation of fluosilicate of sodium and of barium assumed a measurable value at 600° Abs., and of potassium fluosilicate at 700° Abs. Within the region of dissociation of Na_2SiF_6, a saturated solution of NaF in Na_2SiF_6 was obtained when the solution consisted of 20 mols. % NaF and 80 mols. % Na_2SiF_6. A similar relationship existed for $BaSiF_6$ at 50 mols. % of BaF_2. The values determined for the heats of formation were:

	Na_2SiF_6	K_2SiF_6	$BaSiF_6$
Saturated solution	−37,000	−51,100	−31,800 cals.
Infinitely dilute solution	−20,800	−28,500	−26,800 "
Difference (heat of solution of the fluoride in the fluosilicate)	+16,200	+22,600	+ 5,000 "

(*Jour. Soc. Glass Tech.*)

Adsorption and mobilization of potassium ions in colloidal clays. A. DEMOLON. *Compt. rend.*, **182**, 1235 (1926).—The manner in which the potassium ion is combined in lime-containing clays and in clays free from lime was studied. (*Trans. Ceram. Soc.* [Eng.])

Microscopic investigation of the α and β inversions of natural cristobalite. R. WEIL. *Compt. rend.*, **182**, 1949 (1926).—Materials of different origins gave varying results. The temperature of the commencement of inversion varied between 175 and 195°, and of the completion between 205 and 230°. In one case a second interval was observed between 217 and 245°, in addition to the first between 175 and 195°. (*Trans. Ceram. Soc.* [Eng.])

Technical dispersoid analyses. V. HAHN. *Kolloid Zeit.*, **37**, 377 (1925).—The Wiegner sedimentation apparatus and its developments are discussed, in particular the "double-shafted flocculation meter" by Ostwald and V. Hahn. By means of communicating tubes, changes in density in a sedimenting system can be measured. (*Trans. Ceram. Soc.* [Eng.])

Methods of viscosimetry. W. STAUF. *Kolloid-Zeit.*, **37**, 397 (1925).—Viscosity is usually measured by determining the rate of flow through capillaries, to which the Hagen-Poiseuill law is applied. Several viscosimeters are described, including the Engler type, which gives new comparative values. (*Trans. Ceram. Soc.* [Eng.])

Notes on plasticity. A. DE WAELE. *Kolloid-Zeit.*, **38**, 27 (1926).—When a truly viscous fluid flows through a capillary, a linear relation is obtained between rate of flow and pressure. Bingham's parabolic curve for heterogeneous systems is confirmed. Curves for plastic bodies show characteristic discontinuity for low values of the co-ordinates. An equation for the flow of plastic bodies is evolved. See also *Ceram. Abs.*, **5** [8], 260 (1926). (*Trans. Ceram. Soc.* [Eng.])

The plasticity of amorphous and crystalline solids. R. BECKER. *Phys. Zeit.*, **26**, 919 (1925).—A study of the plastic deformability of solids. (*Trans. Ceram. Soc.* [Eng.])

Quartz sand and lump quartz; two different mineralogical modifications. T. SCHEUER. *Sprechsaal*, **59**, 473 (1926).—Optical (mineralogical) investigations indicated that β-quartz is present in quartz sand, and α-quartz in lump quartz. (*Trans. Ceram. Soc.* [Eng.])

Direct determination of trivalent iron in silicates insoluble in acids. O. HACKL. *Zeit. f. analyt. Chem.*, **66**, 401 (1925).—The material is digested with $HF-H_2SO_4$ and titrated with 1/10*N*$TiCl_3$ after adding ammonium thiocyanate. Excess of HF is

counteracted with boric acid. The process is very successful in determining small quantities of ferric iron, *e.g.*, in FeO-compounds. See *Ceram. Abs.*, **5** [7], 230 (1926). (*Trans. Ceram. Soc.* [Eng.])

Preparation of a Czech ceramic terminology. J. MATEJKA. *Zpravy Ceskoslov. Keram. Spol.*, **2,** 16 (1925).—Work has been commenced on a revision of the Czech ceramic terminology, with the ultimate object of issuing a ceramic dictionary in the Czech language. (*Trans. Ceram. Soc.* [Eng.])

A diagrammatic representation of hydrion concentration. MAX TRUMPER. *Am. J. Pharm.*, **99,** 180–82 (1927). (*C. A.*)

Effects of silica dust upon the lungs. I. R. R. SAYERS. *Am. J. Pub. Health*, **17,** 208–14 (1927).—Review under the headings theory of action of SO_2; reaction of the lungs to dust particles; laboratory studies on experimental silicosis; effect of feldspar, china clay, ground pitcher; stages of silicosis; X-ray examinations. (*C. A.*)

Anhydrous borates of silver, barium, and zinc. F. DE CARLI. *Atti accad. Lincei*, **5** [6], 41–47 (1927).—In continuation of previous experiments and using the same method (*cf.* Mazzetti and de Carli, *Ceram. Abs.*, **5,** 228 (1926)) BaO–B_2O_3 and ZnO–B_2O_3 were studied. Because of decomposition of Ag_2O, glasses are very difficult to prepare from Ag_2O and B_2O_3 and are best prepared by adding slowly $AgNO_3$ to fused B_2O_3. The liquids are clear and colorless at first, but become yellow at high concentrations of Ag_2O. Above 61% Ag_2O the high temperature required decomposes the borates and only the range 3–5 molecules of B_2O_3 per molecule of Ag_2O was studied. The thermal diagram showed a maximum at 570° corresponding to the *compound* $Ag_2O \cdot 4B_2O_3$, which was identified as minute white crystals, and its composition confirmed by analysis. With BaO, only mixtures containing 59.48% and more of BaO were studied, since below this region Guertler has already obtained reliable data (*Z. anorg. Chem.*, **40,** 243 (1904)). After the maximum corresponding to the *compound* $BaO \cdot B_2O_3$, the temperature decreased regularly to a eutectic at about 650°, then increased to 810°, corresponding to the *compound* $BaO \cdot 2B_2O_3$. It then decreased to about 605°, then increased to 740°, corresponding to the *compound* $BaO \cdot 3B_2O_3$. A 3rd maximum, with devitrification at 750°, corresponded to the *compound* $BaO \cdot 4B_2O_3$. Above this % B_2O_3, the fusion mixtures separated into 2 layers. Above 75% ZnO liquids could not be obtained with the highest temperature obtainable in an electric furnace, but below 75% ZnO clear liquids were formed. Devitrification occurred readily with all mixtures, and 2 maximum, each at about 900° showed the *compounds* $2ZnO \cdot B_2O_3$ and $ZnO \cdot B_2O_3$. No evidence was found of the *compound* $2ZnO \cdot 2B_2O_3$ (*cf. Compt. rend.*, **77,** 785, 804 (1873)). (*C. A.*)

The identity of crystal structure of the compounds Fe_3S_4 and FeS. C. FONTANA. *Atti accad. Lincei*, **5** [6], 579–81 (1927).—According to Sidot (*Compt. rend.*, **66,** 1257 (1868)) Fe_3O_4 and H_2SO_4 at a red heat form Fe_2S_4. Following in general his procedure, a current of dry H_2S was passed for 2 hrs. at 1000° over artificially prepared Fe_3O_4, whereby a yellowish-gray, granular, crystalline metallic appearing powder was obtained, which analyzed 54.85% Fe and 45.20% S, corresponding to Fe_2S_4. X-ray examination showed, however, no evidence of the compound Fe_2S_4, the S occupying no fixed or characteristic position in the crystalline lattice and the values of a, c, and k being 3.43, 5.69, and 1.665, respectively, which conform to those of troilite (FeS) and β-pyrrhotite as determined by earlier investigations. The reaction of Fe_3O_4 and H_2S at 1000° is accordingly: $Fe_3O_4 + 4H_2S \rightarrow 3FeS + S + 4H_2O$. The presence of S indefinitely oriented in the crystalline lattice has its counterpart in the presence of C in Fe and H_2O in zeolites. Though the present work fails to show the existence of Fe_2S_4, it may be possible to prepare it, in which case it should be similar crystallographically to the compound $(Co, Ni)_2S_4$ identified by Menzer (*Z. Krist*, **64,** 506 (1926)). The failure of

de Jong and Willems (*cf.* abstract p. 479) to prepare Fe_2S_4 conforms to the results of the present work. (*C. A.*)

The heat of combustion of different pure carbons. The existence of amorphous carbon. W. A. ROTH. *Ber. deut. Chem. Ges.*, **50**, 530–36 (1927).—Pure carbon black deposited at different temperatures shows a specific weight and heat of combination different from that of graphite. The lighter the carbon the greater the heat of combustion and the weaker the X-ray pattern of graphite. The difference in energy as much as 300 cal./g between carbon and graphite can hardly be explained on the assumption that carbon black is composed of very small crystals of graphite since this would require either much smaller crystals than is consistent with the X-ray pattern or a much greater surface energy than seems reasonable. (*C. A.*)

Dependence of vapor pressure of stilbite on water content and temperature. L. CHROBAK. *Bull. intern. acad. Polonaise*, 1925A, 333–45; *cf.* Tammann, *J. Phys. Chem.*, **1**, 753 (1897).—The fully hydrated mineral has the composition $CaO \cdot Al_2O_3 \cdot 6SiO_2 \cdot 7H_2O$, part of the Ca being usually replaced by Na, and in a lesser degree by K. Vapor pressures in relation to water content and temperature have been measured, specimens ranging from the almost anhydrated to the fully hydrated form being used. The results show that dehydration and hydration are not entirely reversible. The isobars and isotherms indicate that there are at least 2 stages in the hydration process, the first of which apparently involves the formation of a tetrahydrate. The measurements appear, however, to support the formula $CaAl_2Si_2O_8 \cdot H_8Si_4O_{12} \cdot H_2O \cdot 2aq.$ suggested by Tschermak, 4 molecules of water being combined with silica. The remaining water is present as water of cyrstallization and as adsorbed water. It is, however, impossible to decide whether there are 2 molecules of the former and 1 molecule of the latter or *vice versa*. (*C. A.*)

Hydrogen absorption by sodium and calcium. B. KAMIENSKI. *Bull. intern. acad. Polonaise*, 1926A, 109–28.—Pure Na commences to absorb H appreciably at 100–110°, and more rapidly as the temperature is raised. A mixture of NaH and Na is formed having the melting point of Na (*cf.* Troost and Hautefeuille, *Compt. rend.*, **78**, 807 (1874)). NaH shows the behavior of a salt. CaH_2, prepared by direct union of the elements in an electric furnace, has a heat of formation of 42,383+296 cal. The melting point of CaH_2 is 816.15°. The mean atomic frequency of Ca and Li hydrides at the melting point calculated from Lindemann's formula, is greater than for the corresponding halides, the order being $H > F > Cl > Br > 1$. The conductivity of CaH_2 increases 20 times at the melting point which, together with other facts, indicates that the compound has the character of a salt in which the negatively charged H ion appears. The hydrolysis of boroethane is readily explained on this basis by supposing that 6 negative ions neutralize 6 positive H ions (from water) with the formation of free H. (*C. A.*)

Thermal and microscopical investigations of the cupola-furnace slag systems MnO–Al_2O_3–SiO_2, MnS–$MnSiO_3$, and CaS–$CaSiO_3$. O. GLASER. *Centr. Mineral Geol. Abt., App.*, 81–96 (1926).—The binary systems Mn–SiO_2, Al_2O_3–SiO_2, and MnO–Al_2O_3 were first examined and the results of earlier investigations confirmed. The system MnO–SiO_2 has a compound $3MnO \cdot 2SiO_2$ which decomposes at the melting point as does the corresponding Ca compound. The addition of Al_2O_3 to mixtures of MnO and SiO_2 depresses the melting point up to a content of 20–25% Al_2O_3, a further addition causing it to rise again. The compound $2MnO \cdot Al_2O_3 \cdot SiO_2$ melts at 1175°, while $MnO \cdot Al_2O_3 \cdot 2SiO_2$ melts at 1130°. The system MnS–$MnSiO_3$ shows in a liquid form a limited solubility and in the solid form, as seen from metallographic investigation, complete immiscibility. The eutectic is at 6% MnS and melts at 1080°, while the gap in solubility is between 13 and 40% MnS. The system CaS–$CaSiO_3$ shows in the fluid condition a miscibility gap at 12–40% CaS, while in the solid state it seems to

separate into its component parts. The eutectic is at 3% CaS and melts at 1440°. (*C. A.*)

Influence of water and carbon dioxide under pressure on molten and solid silicates. R. ZÜNCKEL. Dissertation, Weimar, 1914.—No work previously done on this subject owing to difficulty of obtaining a material to withstand high pressures at 1200–1400°. In the present work, an insulated electric furnace was inclosed in a larger cast iron vessel, which successfully stood high pressures. A characteristic of obsidian was its swelling in the blowpipe flame owing to expulsion of gas, giving pumice. Melts were carried out at 1200° in a Hemple oven. These melts, based on an obsidian of composition SiO_2 73.97, Al_2O_3 12.91, Fe_2O_3 0.88, FeO 0.77, CaO 0.48, MgO 0.49, K_2O 5.01, Na_2O 3.81, loss on ignition 1.26, contained the minor constituents as in obsidian, but the silica and alumina were varied. Glasses resembling obsidian were obtained. Using the apparatus described, melts were obtained under high water pressure which on heating showed the characteristic obsidian swelling. This swelling could also be obtained if the water vapor pressure were suddenly lowered. The melts on analysis were found to contain water, the content being increased by raising the pressure of the water. Variation of the silica and alumina contents had no influence on the water content. Similar results were obtained with carbon dioxide, the swelling phenomenon again taking place. The effect of sodium chloride on silicate melts was investigated. A chloro-compound insoluble in water and acids was found, in addition to the taking up of soluble chloride. Iron introduced in the ferrous condition gave colorless melts while ferric iron gave dark green glasses. Experiments were conducted in an iron pressure vessel, which was well lagged and provided with gas heating. Temperatures up to 420° were reached. Bohemian potash glass, soda glass, Vesuvius lava, liparian obsidian, pitchstone, volcanic ash, fumarole product, aluminium shale in a fine state of division were heated under high water pressure. The solubility was found to increase up to the critical temperature of the water, above which the solubility remained sensibly constant. Carbon dioxide pressure had a marked influence, increasing the solubility of alkali. Vitreous silicates were found to be much more soluble than crystalline silicates. No new crystalline minerals were formed, either under water pressure or carbon dioxide pressure. (*Jour. Soc. Glass Tech.*)

Dispersion of metals. JOSEPH FISCHER. *Fortschritte Chem., Physik, physik. Chem.*, **19**, 1–70 (1926).—A monograph on dispersion of metals, particularly by mechanical thermal means (Berliner and Goetz) and by electric evaporation (Kohlschütter, Güntherschulze, Kingdon and Langmuir, G. E. Co., London). Theory (Stark, Kingdon and Langmuir, Thomson) and practice are extensively discussed. A bibliography of 43 titles is attached. (*C. A.*)

Fused electrolytes—an historical sketch. C. J. BROCKMAN. *J. Chem. Education*, **4**, 512–23 (1927). (*C. A.*)

Reactions of chromates at high temperatures. II. The system lime-chromium oxide-oxygen. K. S. NARCUND AND H. E. WATSON. *J. Indian Inst. Sci.*, 9A, 149–67 (1926).—In part I (*C. A.*, **18**, 3154) it was shown that pure $CaCrO_4$ decomposes very slightly on heating to 1000° in air, decomposition being increased by the addition of CaO. The conditions under which decomposition takes place and intermediate compound formation have now been studied. The decomposition products appear to be: $Cr_2O_3 \cdot CrO_3 \cdot 3CaO$, $\frac{3}{2}Cr_2O_3 \cdot CrO_3 \cdot 4CaO$, and $2\,Cr_2O_3 \cdot CrO_3 \cdot 5CaO$. Tables showing the percentage decomposition of $CaCrO_4$ at different pressures, the oxidation effects during cooling and the decomposition of $CaCrO_4$ in air are given. CrO_3 was heated as $CaCrO_4$ was, and the results are tabulated. $CaCr_2O_4$ appears to behave on heating as if it were a mixture of $CaCrO_4$ and CrO_3. $CaCrO_4$ and CaO were heated in air. The formula $CrO_3 \cdot \frac{3}{2}CaO$, appears to represent this basic chromate. Tabulations are given of the

dissociation pressures of mixtures of CaO and $CaCrO_4$, the pressure of gas evolved from the mixture at 910°, the quantities of gas evolved from mixtures of CaO+$CaCrO_4$, and the effect of heat upon mixtures of varying composition *in vacuo*. When heating $CaCrO_4$ and Cr_2O_3 in mixtures of varying composition *in vacuo*, Ca chromite is obtained. For 0.5 molecules of Cr_2O_3 the formula becomes $Cr_2O_3 \cdot CaO$, described by Guber (*Bull. soc. chim.*, **27** [2], 435 (1877)) and Dufan (*Ann. Chim. Phys.*, **12** [7], 266 (1897)). The interpretation of the results obtained when heating CaO and Cr_2O_3 in different proportions is not very simple. On admitting measured quantities of O_2, the pressure at no time being allowed to rise above 20 mm, to mixtures of CaO and Cr_2O_3, O_2 is rapidly absorbed but after a short interval the gas is again liberated. (*C. A.*)

Diffusion of aqueous sodium silicate solutions across semipermeable membranes. PHANI BHUSAN GANGULY. *Jour. Phys. Chem.*, **31**, 407–16 (1927).—A study of the diffusion of Na silicate solutions through membranes of parchment and collodion showed that the silica concentration in the original compartment was generally greater than that in the other compartment after equilibrium was attained. The quantity of nondiffusible matter was slight when the $SiO_2 : Na_2O$ ratio was less than 3, but above this value the amount of nondiffusible matter increased rapidly. The amount of Na in the silicate compartment was also greater than in the H_2O compartment. The colloidal matter probably consists of molecular aggregates or ionic complexes containing both Na and SiO_2. Measurements of p_H of the solutions after equilibrium showed that hydrolysis does not play any important rôle during the distribution process. (*C. A.*)

Mechanism of coagulation. V. V. LEPESHKIN. *Kolloid Zeit.*, **36**, 41–47 (1926).—The difference between irreversible and reversible coagulation lies in the formation of adsorption compounds by the colloid particles and in their nonhydration, in the first case. Arsenious sulphide may, by dialysis and cataphoresis, be made to show reversible coagulation. The irreversible coagulation of this sol is caused by the formation of adsorption compounds with salts, which are not decomposed by water. Dilute HNO_3 in the cold and dilute KOH at high temperatures, however, decompose them without destroying the colloid. The addition of alcohol by lowering the dielectric constant of the water accelerates the coagulation of the sol, while greater concentrations of alcohol retard it on account of the depression of the ionization of the coagulating salt. Ether emulsion in the presence of salts brings about a rapid coagulation of the sol, due to adsorption on the drop surfaces. Dissolved ether causes no alteration in the coagulation velocity, but if mixed with alcohol diminishes it. The raising of the inner friction of the sol by the addition of agar-agar completely stops coagulation, while the addition of glycerol or sugar retards or stops it according to the quantity added. (*C. A.*)

General colloid chemistry. XIX. Constitution of silicic acid sols. 2. W. PAULI AND VALKÓ. *Kolloid-Zeit.*, **38**, 289–300 (1926).—Silicic acid sols as prepared by Grimaux (*Compt. rend.*, **98**, 105 (1884)) by the saponification of tetramethyl orthosilicate are not completely free from electrolytes, but the latter may be removed by electrodialyzing the sol for a few hours. The products have an H-ion concentration of 1.3 to 3.4×10^{-5} *N* and a specific conductivity of 4.6 to 13.6×10^{-6} mho. The composition of the colloid particles may be represented by the formula $[x(SiO_2 + nH_2O) \cdot ySiO_3H'] + yH$; already advanced for the Graham sol in the previous communication. The number of molecules associated with 1 charge (x/k in the formula) varies between 6000 and 15,000 for the Grimaux sols, *i.e.* about 10 times the values found for the Graham sols. This difference is attributed to the fact that the latter sol is prepared in a solution having a high H-ion concentration, while in the former case the solution is practically neutral. Grimaux sols with 1–2% SiO_2 are stable for some weeks. Jellies form gradually, but they may be redispersed merely by shaking; the conductivity, however, remains unchanged. In migration velocity determinations by the direct macroscopic

method, the velocity of the sol-electrolyte boundary is influenced greatly by the nature of the electrolyte. The migration velocity of the particles in the Graham sol is estimated to be 20×10^{-5}, and in the Grimaux sol 10×10^{-5} cm/sec. All the particles carry charges. The addition of KCl or $BaCl_2$ diminishes the velocity, while $NaHCO_3$ increases it. In the latter case, a considerable increase in the charge number of the particles takes place. The decrease of conductivity brought about by the addition of HCl to silicic acid sols is due to a decrease in the H-ion concentration consequent on the formation of positively charged particles according to the scheme $[x(SiO_2+nH_2O)\cdot ySiO_3H\cdot] +yCl'$. (*C. A.*)

Transformations of iron in nature. I. Theoretical considerations. H. O. Halvorson and R. L. Starkey. *J. Phys. Chem.*, **31**, 626–31 (1927).—From a theoretical study of transformations of Fe in pure solutions equations have developed which indicate the relationships between the activities of the ferrous, ferric and H ions and O_2 concentration. Measurements indicate that at reactions more alkaline than $p_H=5.0$ very small quantities of ferrous Fe will occur in solution under atmospheric conditions and even smaller quantities of ferric Fe are soluble. (*C. A.*)

Properties of alkaline silicic acid sols. H. Freundlich and H. Cohn. *Kolloid Zeit.*, **39**, 28–35 (1926).—The sensitization of silicic acid sols caused by the addition of alkalis (Flemming, *Z. physik Chem.*, **41**, 427 (1902)) has been confirmed by measurements of the coagulation of different sols made alkaline with KOH of NH_3, by Li, Na, K, and Ba chlorides, and $Ca(NO_3)_2$ and $MgSO_4$. The change from a hydrophile sol to one with distinctly hydrophobe properties was observed and shown to be due to the presence of the alkali. The charge on the silica particles in alkaline sols was measured by means of a new cataphoresis apparatus which eliminates any effects due to the migration of silicate ions. The gradual transformation from sol to silicate solution brought about by the addition of alkali has been followed by means of conductivity and p_H measurements and dialysis experiments. The alkali sensitization is considered to be due to dehydration of the silica particles; viscosity measurements, observations of the appearance and condition of the coagulate, and the fact that some other hydrophile sols exert a strong protective action on the sensitized sol contribute to this conclusion The flocculation observed sometimes when silicic acid and albumin sols are mixed (Mylius and Groschuff, *Ber.*, **39**, 116 (1906)) occurs with certainty only if the sols are neutral. (*C. A.*)

Influence of nonelectrolytes on the precipitation of colloids by electrolytes and on the adsorption of ions. K. C. Sen. *Kolloid. Zeit.*, **38**, 310–14 (1926).—The coagulation of MnO_2 sol by Cu sulphate and by $AgNO_3$, in the presence of EtOH and of sucrose has been studied. Sucrose and EtOH stabilize the sol against Cu sulphate, the former to a high, and the latter to a low degree. With $AgNO_3$, sucrose exerts no appreciable effect, while EtOH sensitizes the sol. The adsorption of Cu sulphate and $AgNO_3$ by air-dried hydrated MnO_2 is increased considerably by the addition of the above nonelectrolytes. The conclusion of Weiser that adsorption of a nonelectrolyte lowers the adsorption of an electrolyte, is not therefore generally valid. The effect of nonelectrolytes on colloids is discussed, and it is shown that the above cases are anomalous and not susceptible to any simple explanation. The nature of the nonelectrolyte is evidently of some significance. (*C. A.*)

Wetting adsorption. Adsorption of deformable substances. O. Bartsch. *Kolloid Zeit.*, **38**, 321–28 (1926).—A stalagmometric method for determining the adsorption of oleic acid is described. From the results of measurements with a variety of adsorbents, it is shown that the wettability of the absorbents by water and by oleic acid is of great influence on the process. The thickness of the layer of adsorbed oleic acid can amount to many thousand molecules. With special regard to the deformability of the adsorbed

liquid particles under the influence of the phase boundary forces, an explanation is given of the formation of powerfully adsorbed layers, without invoking the assistance of molecule attraction and without conflicting with Langmuir's theory of a unimolecular layer. (*C. A.*)

Selenium and tellurium dispersoid solutions with varying particle size. R. AUERBACH. *Kolloid Zeit.*, **38,** 343–47 (1926).—From cryoscopic measurements, it is found that metalloid Se dissolves in pyrosulphuric acid as diatomic molecules. Metalloid Se of any degree of dispersion changes at 130° into a metallic modification. In a molecularly dispersed solution this change is due to a breaking down of Se_2 molecules into single atoms. It is accompanied by a color change from green to yellow. By the addition of water to solutions of Se_2, in pyrosulphuric acid, with consequent increase in the particle size, at 20° the color changes from green through yellow and red to violet, and the metalloid is then precipitated while above 130° the color change is from yellow, through red, to blue and the metallic form is deposited. In both cases, the color change is in accordance with Ostwald's color dispersity rule. If, however, the yellow metallic solution is coagulated at the ordinary temperature the first result is the re-formation of the Se_2 molecules accompanied by the change from yellow to green, *i. e.* in opposition to the color-dispersity rule. After this, the color changes proceed in the normal manner and finally the metalloid is precipitated. Te, in accordance with its metallic character, dissolves in pyrosulphuric acid only as single atoms. On coagulation the color changes from red, through violet, to blue, in accordance with Ostwald's rule. Spectrophotograms of Se (in both forms) and of Te solutions are shown and their relation to the cryoscopic results is indicated. (*C. A.*)

Sensitizing sols by small quantities of other colloids. S. GHOSH AND N. R. DHAR. *Kolloid Zeit.*, **41,** 229–34 (1927).—The sensitizing of positively charged sols as $Fe(OH)_3$, $Cr(OH)_3$, $Al(OH)_3$, dyes, etc., by means of negative colloids as gelatin, albumin, tannin, etc., depends largely on the neutralizing action. The sensitizing of negative sols as As_2S_3, Sb_2S_3, Mo_2O_5, SiO_2, Ag, Au, etc., by gelatin, albumin, tannin, etc., is explained by (1) the hydrolysis being hindered by the small quantity of H ion contained in the gelatin, tannin, etc., and (2) by gelatin, albumin, etc., acquiring positive charges depending on the H-ion concentration. (*C. A.*)

Chemical study of some feldspars. KUNIKATSU SETO. *Sci. Repts. Imp. Tôhoku Univ.*, (III), **1,** 219–31 (1923).—Analyses of orthoclase indicate that the molecule $K_2O \cdot Fe_2O_3 \cdot 6SiO_2$ is present in solid solution with other K and Na feldspar molecules. Sixteen new feldspar analyses are given including adularia, moonstone, sanidine, soda-orthoclase, perthite and orthoclase. (*C. A.*)

A new mineral, kôchite ($2Al_2O_3 \cdot 3SiO_2 \cdot 5H_2O$). S. KÔZU, K. SETO, AND K. KINOSHITA. *Sci. Repts. Tôhoku Imp. Univ.*, **2,** 1–7 (1924–25). (*C. A.*)

The influence of temperature on the path difference and on the schillerization in soda-orthoclase and moonstone. SHUKUSUKÉ KÔZU AND MINÉICHI MASUDA. *Sci. Repts. Tôhoku Imp. Univ.*, **3,** 1–9 (1926).—The change in path difference of transmitted light, schillerization, thermal expansion and Laue X-ray photographs show 3 temperatures 500°, 700°, and 900° at which changes take place at special rates in soda-orthoclase and Ceylon moonstone. (*C. A.*)

Ternary diagram of the system iron-carbon-copper. T. ISHIWARA, T. YONEKURA, AND T. ISHIGAKI. *Sci. Repts. Tôhoku Imp. Univ.*, **15,** 81–114 (1926).—The ternary diagram of the system Fe-C-Cu has been constructed for the Fe corner and for alloys containing up to 30% Cu, from the phase-rule considerations based on the known binary diagrams, Fe-cementite and Fe-Cu and on a somewhat hypothetical diagram for the system cementite-Cu. The positions of the most important lines and points have then been checked by thermal and micrographical analysis of the corresponding alloys,

and found to agree reasonably well with the theoretical positions. At 1100°, there is an invariant point corresponding with a concentration of 4.3% C and 3.3% Cu at the intersection of the eutectic and monotectic lines. The maximum concentration of the γ solid solution is about 3.5% C and 3.8% Cu. The eutectoid line starts from the binary Fe-Cu eutectoid point at 2.3% Cu and 833° and gradually descends, the Cu content decreasing as the C increases. Addition of Cu to steel lowers the Al transformation point 20° with 2% Cu; the eutectoid invariant point corresponds with a composition of 0.9% C, 1.75% Cu and 97.35% Fe at 700°. Saturation of Fe with Cu to give a uniform solid solution lowers the A_2 point by about 10°. (*C. A.*)

Blast-furnace slags containing titanium. ALFRED STANSFIELD AND J. E. MORRISON. *Trans. Roy. Soc. Can.*, **20,** 439–43 (1926).—The fusibility of mixtures of CaO, SiO_2, Al_2O_3, TiO_2, and Ti_3O_5 in varying proportions was determined in order to obtain information regarding the smelting of Ti-containing Fe ores. The Al_2O_3 content was kept constant at 10% of each mixture. The "softening point" was recorded as the temperature at which the tip of a cone of the mixture became level with the base. Triangular graphs of the 2 series SiO_2, Al_2O_3, Ti_3O_5 in a reducing atmosphere and SiO_2, Al_2O_3, TiO_2 in an oxidizing atmosphere are given. The formation of a refractory compound of Ti under conditions obtaining in the blast furnace (probably a nitride of Ti) is recorded and the suggestion made that the mystery enshrouding the treatment of titaniferous ores will soon be cleared up. (*C. A.*)

Equilibrium between molten metals and salts. C. TUBANDT AND ERNST MÜNZING. *Z. anorg. allgem. Chem.*, **160,** 323–32 (1927).—The equilibria (Pb, Ag, $PbCl_2$, AgCl) and (Cu, Ag, CuCl, AgCl) were determined in molten condition. The equilibrium (Pb, Ag, $PbCl_2$, AgCl) is easily approached from both sides and is markedly dependent on temperature. The presence of NaCl or KCl causes no marked displacement of the equilibrium. Both equilibria are in good agreement for all concentrations with the K. Lorenz and van der Waals-Laar theory of vapor tension and mass action formulation for condensed systems. (*C.A.*)

Surface tension and viscosity of aqueous solutions of potassium, sodium, lithium, thallium and barium hydroxides, and sodium carbonate solution. O. FAUST. *Z. anorg. allgem. Chem.*, **160,** 373–76 (1927).—The surface tensions were measured by the drop weight method. Surface tensions and viscosities were determined at 20°, for concentrations up to 6 *N*. (*C. A.*)

Constitution of boron compounds. J. A. CHRISTIANSEN. *Z. anorg. allgem. Chem.*, **160,** 395–403 (1927).—Structural formulas for chain and cyclic B hydrides have been assigned using the concepts of valence and coördination number or the atoms in direct combination with other atoms. (*C. A.*)

The compounds Fe_3S_4, Co_3S_4, Ni_3S_4 and their structure. W. F. DE JONG AND H. W. V. WILLEMS. *Z. anorg. allgem. Chem.*, **161,** 311–15 (1927).—The X-ray diffraction pattern, by the powder method, of linnéite ($5Co_3S_4 \cdot 6Ni_3S_4$, from Littfeld) is similar to that of magnetite. The data indicate that linnéite crystallizes in the regular system, and that the edge of the unit cube which contains 8 mols. is equal to 9.36 A. U. Pure Co_3S_4, prepared by heating CoS in an H_2S atmosphere, gave an identical diffraction pattern. Polydymite (Ni_3S_4, from Grünan) gives a pattern similar to that of linnéite. The edge of the unit cube is equal to 9.65 A. U. The authors were unable to prepare Ni_3S_4 or Fe_3S_4 by the methods claimed in the literature. (*Cf.* C. Fontana, p. 473.) (*C. A.*)

Determination of the acidity or alkalinity of different glasses by means of the quinhydrone ionometer of Prof. Lüers. A. MAURI. *Chem.-Ztg.*, **51,** 284 (1927).—Three glasses were tested with water having a p_H value of 5.43. At room temperature the values 5.65, 4.75, and 5.75 were obtained, with the water in contact with the glasses, but after heating to 135° in the glass, the corresponding values were 5.45, 5.62, and 5.75. (*C. A.*)

Sedimentation analysis. SVEN ODEN AND N. WINCKLER. *Tekn. Tids.*, **57** (Kem. Afd.) 16–18 (1927).—Graphs show the application of a statistical sedimentation analysis (*C. A.* **20,** 1005; **21,** 1071) to nonkaolin materials, *e.g.*, Carborundum, graphite, SiO_2 gel, cocoa, etc. (*C. A.*)

Anomalous flocculation of clay. N. M. COMBER. *Nature*, **118,** 412 (1926).—Polemical (*cf.* Joseph and Oakley, *C. A.* **20,** 2439). The significance of the results is entirely dependent on what is meant by a "highly purified clay," *i. e.*, on the complete removal of adventitious and absorbed Ca. (*C. A.*)

The active forms of silicic acid (silica gel) and their adsorptive capacities. OTTO RUFF AND PAUL MAUTNER. *Z. angew. Chem.*, **40,** 428–34 (1927).—A summary of information concerning natural and artificial silica, with a bibliography containing 85 references. (*C. A.*)

The temperature curve and heat flow in periodically heated walls of variable heat conductivity. H. KORNFELD. *Z. tech. Physik*, **8,** 178–83 (1927).—A discussion of different calcination methods (Schwarz, *Z. tech. Physik*, **6,** 554 (1925), Schlüter, *Mitt. d. Warmestelled. Ver. deutscher Einsenh.*) for heat flow and temperature gradient of oven walls. K. has worked out a new approximation method to be published in *Z. angew. Math. Mechanik.* (*C. A.*)

BOOKS

Forschungen zur Kristallkunde: I. Trachten der Kristalle. (Researches in the Science of Crystals: I. The Habit of Crystals.) H. TERTSCH, Univ. of Vienna. Berlin; Borntrager, 1926, viii+222 pp. 58 figs. 17x25 cm. Price 15 M. Reviewed in *Jour. Am. Chem. Soc.*, **49** [8], 2124 (1927).—This is the first of a new series of monographs on crystallography and related subjects, under the editorship of Arrien Johnsen, of the Univ. of Berlin. R.J.P.

Subject Index to Periodicals: Section K. Science and Technology, 1922. London: The Library Association. Grafton & Co., 1927. Price one guinea. H.H.S.

PATENTS

Process of mining insoluble boron compounds. HENRY BLUMENBERG, JR. U. S. 1,636,455, July 19, 1927. A method of mining water insoluble calcium boron compounds comprising introducing a hot calcium chloride solution to the calcium boron deposit, thereby disintegrating and dissolving a portion thereof, removing and cooling the resulting magma, thereby causing a portion of the dissolved calcium boron compounds to precipitate and remove the soluble part from the insoluble part of the magma, said soluble part containing calcium chloride and a small percentage of calcium boron compounds in solution.

Process of mining insoluble boron compounds. HENRY BLUMENBERG, JR. U. S. 1,636,456, July 19, 1927. A method of mining water insoluble calcium boron compounds comprising introducing a hot ammonium chloride solution to the calcium boron deposit, thereby disintegrating and dissolving a portion thereof, removing and cooling the resulting magma, thereby causing a portion of the dissolved calcium boron compounds to precipitate and removing the soluble part from the insoluble part of the magma, said soluble part containing ammonium chloride and a small percentage of calcium boron compounds in solution.

Process for dissolving a mixture of hafnium and zirconium phosphates and for separating hafnium and zirconium. ANTON EDUARD VAN ARKEL AND JAN HENDRIK DE BOER. U. S. 1,636,493, July 19, 1927. A process of converting a mixture of hafnium and zirconium phosphates, characterized in that said hafnium and zirconium phosphates are introduced into a medium containing phosphoric acid.

Phosphorescent luminous enamel. FERNAND SAUVAGÉ. U. S. 1,637,963, August 2, 1927. A method of rendering objects luminous in the dark consisting in coating the objects with layers of a mixture of a varnish and phosphorescent zinc sulphide, and drying the article after each coating at a temperature of about 65°C and increasing the temperature by 10° after the application of each layer.

Gems. J. F. RIERS. Brit. 271,136, July 13, 1927. Aquamarine stones are made synthetically by fusing a powdered mixture of silica, oxide of glucinium, and alumina, colored with a medium of which nitrate of cobalt is the basis, and molding reheated pieces of desired size formed by breaking up the product of fusion. The molded stones are subsequently cut and polished. In an example, 90 g of rock crystal are pulverized and mixed with a coloring bath. 20 g of hydrated alumina and a similar amount of hydrated or anhydrous oxide of glucinium are added, and the whole fused with the aid of a flux comprising 30 g of carbonate of lithia or caustic lithia, 15 g of fused boric acid, and 4 g of sodium borate, in an oxyacetylene, oxyhydrogen, or electric furnace.

Zinc sulphide, sodium zincate, zinc oxide, and lithopone. A. MOULIN AND E. BERGER. Brit. 272,517, August 4, 1927. Zinc is recovered from any source by treatment with an alkaline solution, preferably caustic soda, to obtain a solution of sodium zincate, which is freed from sediment by centrifugal treatment, agitated with air, and filtered through asbestos. The solution is diluted and saturated with carbonic acid, whereby zinc oxide is precipitated, and the solution, after being made caustic is filtered and concentrated for the recovery of soda. The zincate solution is treated with hydrogen sulphide or zinc sulphide to precipitate zinc sulphide. To obtain lithopone, sodium sulphate is added in calculated quantity to the zincate solution, followed by a solution of barium sulphide; caustic soda is also formed. Zinc ores are roasted if they contain sulphur, washed with sulphuric acid to dissolve all the metals and then heated with an excess of soda to form a solution of sodium zincate.

Purifying minerals (silica, etc.). H. GRÜNWOLDT. Brit. 258,246, Aug. 28, 1926. Natural or artificial rocks, particularly feldspar and silica, are treated with sulphuric acid or a mixture of sulphuric and hydrochloric acids, together with an organic acid (oxalic) or a salt of such acid, either cold or with the application of heat. (*Trans. Ceram. Soc.* [Eng.])

General

What has the past one hundred years done to the brick business in the U. S. A.? EDITORIAL. *Bull. Amer. Ceram. Soc.*, **6** [8], 231–32 (1927); reprinted from *National Bulletin*, "Weekly News Letter, No. 348," C. B. M. A., June 11, 1927.—A comparison of 2 events in 1828 and 1927 is made to show the progress of the last 100 years. A check-up of the brick industry during the last 100 years also shows marked progress in manufacturing methods but there is still room for betterment, particularly in merchandising. E.J.V.

Flint and Lime Glass Manufacturers hold successful meet at Atlantic City. ANON. *Amer. Glass Rev.*, **46** [43], 15 (1927); *Nat. Glass Budget*, **43** [12], 3 (1927); *Pottery, Glass and Brass Salesman*, **35** [25], 9–13 (1927); *Glass Ind.*, **8** [8], 202 (1927).—A well attended meeting of the American Association of Flint and Lime Glass Manufacturers was held at Atlantic City on July 18. C. M. Rodefer was re-elected president. E.J.V.

Experience—a help or a hindrance? S. O. PHILLIPS. *Brick Clay Rec.*, **71** [3], 170–74 (1927).—A thorough discussion in which it is shown that (1) habitual actions offer least resistance, (2) it is common practice to cling to things and methods which are known, and (3) to mistrust a man who looks ahead. The governing rule has been experience and everyone is told that present practices are the most efficient that can be devised but this is a false statement as striking examples of efficiency in business can be cited to disprove it. E.J.V.

New Jersey clayworkers discuss tariff and cost accounting at well attended summer meeting. ANON. *Clay-Worker*, **88** [1], 25–27 (1927).—A report of the meeting held at Asbury Park, N. J., on June 10. See also *Ceram. Abs.*, **6** [9], 410 (1927). E.J.V.

Costs and accounting as applied to the clay industry. R. C. TURNER. *Clay-Worker*, **88** [1], 38–39 (1927).—The sixth and last of a series of articles on this subject. The value and importance of statistical records in the clay industry are discussed under subtopics of cost records and statistics, analysis of cost, sales records and statistics, analysis of sales records, budget estimate of sales, budget of production and operations, the value of certain products, analytical accounting, and the mainspring of the business. See *Ceram. Abs.*, **6** [8], 362 (1927). E.J.V.

Factory management. S. S. COCHRANE. *Nat. Glass Budget*, **43** [14], 3 (1927).—A full report of the address on this subject delivered before the Glass Container Association at Niagara Falls on July 29. E.J.V.

Report of Glass Container meeting at Niagara Falls. ANON. *Nat. Glass Budget*, **43** [14], 3 (1927); *Amer. Glass Rev.*, **46** [45], 15–18 (1927).—The summer meeting of the Glass Container Association was held at Niagara Falls, Canada, on July 28 and 29. E.J.V.

Pottery Managers' and Officials' Association. Visit to Berry Hill Brickworks. ANON. *Pottery Gaz.*, **52** [602], 1273–75 (1927).—A description of the clay mines and Brickworks Department of the Berry Hill Collieries, Ltd., Fenton Manor, Stoke-on-Trent, visited by members of the Association on July 2, 1927. Various interesting features in plant equipment are described. E.J.V.

The Ceramic Society's tour in Czechoslovakia and Austria. III. ANON. *Pottery Gaz.*, **52** [602], 1286–93 (1927).—In a paper by R. Barta on "The Ceramic Industry in Czechoslovakia" many interesting points were set forth. Czechoslovakia is the richest country in ceramic raw materials in Europe, aside from England. It is next to England as a kaolin producer with an output estimated at 400,000 T per year. Refractory clays, faience clays, stoneware clays, etc., have an output of 500,000 T per year. Feldspar, quartz, and schists are produced to the extent of 30,000 T, 470,000 T, and 150,000 T per year, respectively. There are produced two billion bricks and 200 million roofing tiles while 300,000 T of refractories are made yearly. Pottery, stoneware, wall and stove tile, porcelain, and glass are also produced extensively. Schools and organizations for the ceramic industries are listed. Several other papers were presented in summary form. After a separate banquet of the English Ceramic Society, a visit was made to the West Bohemian Kaolin and Chamotte Works at Horni Briza, where a kaolin pit producing 60,000 T annually was inspected. For Part I see *Ceram. Abs.*, **6** [8], 362 (1927); for Part II see *Ceram. Abs.*, **6** [9], 411 (1927). E.J.V.

Industrial ventilation with particular reference to hot and dusty trades. C. P. YAGLOU. *Fuels and Fur.*, **5** [8], 977–85 (1927).—The physiological effect of dusts, fumes, and vapors are discussed and methods for removing them from the air are given. Hazards due to the evolution of arsene during pickling operations are pointed out. Exposure to excessive heat causes fatigue and ill health. Glassblowers are mentioned in this connection. Humidity and air movement must be taken into account as well as temperature. The use of the "effective temperature index" is illustrated by means of a chart. Experimental data are used in showing that high effective temperatures decrease output, that poor ventilation causes excessive reduction in output in the summer, that accidents are less frequent at normal temperatures, and that sweating causes a loss in salt which may be counteracted by additions to the drinking water. Where heavy work is being done the effective temperature should not exceed 80%. Y. describes methods by means of which the effective temperature can be kept below this figure. A.E.R.W.

Researches on the theory of fine grinding. Pt. VII. On the efficiency of grinding machines and grinding media with special reference to ball and tube mills. GEOFFREY MARTIN. *Trans. Ceram. Soc.* [Eng.], **26** [5], 34–44 (1926–27).—The efficiency of a grinding machine is defined as the work performed by the machine in ft.-lb. in increasing the surface of standard Leighton Buzzard sand by 1 sq. ft. The absolute grinding efficiency of machines can be calculated from the heat of volatilization of brittle crystals and their molecular dimensions. It has been proved that the work done in grinding is proportional to the surface produced, this being a statistical result similar to the law of extension of liquid films. Consequently, the work required in grinding to any requisite degree of fineness may be calculated from the formula:

$$W = B(S_2 - S_1)$$

where W is the work required in ft-lb.; S_1 and S_2 are the original and final surfaces of the powder; B is a constant measuring the efficiency of the machine, being the work required to increase the surface by 1 sq. ft. Experimental results are given of the effect of using various grinding media in tube and ball mills. The most efficient media were ¾-in. steel balls, followed by 1-in. steel balls. Flints are extremely inefficient. A relationship exists between the surface of the balls in the mill and the surface of the sand being ground, efficiency only being maintained when the surface of the sand exceeds the surface of the balls by from 100 to 500 times. As the surface of the sand increased or diminished beyond these limits, the surface presented by the balls had to be changed. The best speeds of revolution, the best per cent load and volume of the balls and charge, and the influence of size of machine on efficiency were investigated. Grinding in a current of air did not noticeably increase the efficiency. R.F.S.

Researches on the theory of fine grinding. Pt. VIII. On the variation in the specific gravity of quartz sand on prolonged grinding. GEOFFREY MARTIN. *Trans. Ceram. Soc.* [Eng.], **26** [5], 45–56 (1926–27).—By grinding standard sand (average particle size, 0.75 mm) from 25 to 50 minutes, the density increases by about 0.1% (from 2.650 to 2.653). There is a distribution of densities among the particles according to their size and the density of a given sample of quartz is dependent on the grain size of the sample. Reduction in the grain size of quartz from 0.75 mm to 0.30 mm does not apparently affect the specific gravity. Reduction in the grain size of quartz from 0.30 mm to 0.03 mm causes an increase of specific gravity from 2.650 to 2.655, an increase of 0.2%. Reduction in particle size from 0.03 mm downward causes the density to fall from 2.655 to 2.653, *i.e.*, by 0.07%. If this decrease is due to the formation of amorphous silica, we can say that grinding standard sand for 25 to 50 minutes results in the production of 0.46% of amorphous silica, but the presence of this is confined to the particles below a particle size of 0.03 mm. Prolonged mechanical grinding of quartz causes a reduction in specific gravity. A table shows that the fall of specific gravity, and hence the amount of amorphous silica formed, varies directly as the time of grinding, *i.e.*, directly as the work done, after the phenomenon of the increase of specific gravity has ceased. R.F.S.

Note on sieving. H. H. STEPHENSON. *Trans. Ceram. Soc.* [Eng.], **26** [5], 59–60 (1926–27).—The material was bull-quartz, chosen so that no question could arise of a mixture of materials, one softer than the other, grinding against each other. The sieve was 200-mesh copper, practically new. The quartz had passed a 183-silk mesh. The figures given show the per cent of material which passed through the sieve in one-minute stopwatched intervals. The standard specification says that sieving should be continued until not more than 0.1% of material passes through in one minute. It will be seen, on referring to the figures, that this occurred in the 48th minute and then not again until the 57th minute. If sieving had been continued, there would have been found several wave-crests which were over 0.1%, but the figures between the 48th and

57th minutes show that to stop sieving the first time a minute-yield drops to 0.1%, gives a result 1.33% too low for the material passing through. This is important in the abrasive industry. R.F.S.

Continuity of operation. R. M. HUDSON. *Ceram. Ind.*, **9** [2], 140 (1927).—A description of the causes for shutdowns and lay offs. It is shown that simplified practice cuts down waste. F.P.H.

Favor American valuation of imports. ANON. *Ceram. Ind.*, **9** [2], 174 (1927).—Report of the annual meeting of the American Association of Flint and Lime Glass Manufacturers. F.P.H.

How cost accounting is applied. E. J. BORTON. *Ceram. Ind.*, **9** [2], 164–72 (1927).—In this 3rd article on cost finding in the pottery industry actual operation of the system previously outlined is described. For Part I of this series of articles see "Three Methods of Cost Accounting," *Ceram. Abs.*, **6** [8], 361 (1927); for Part II, *ibid.*, [9], 411 (1927). F.P.H.

The purification of clay. ANON. *Master Builder*, **61**, Feb. (1927); *Tonind. Ztg.*, **51** [28], 476 (1927). F.P.H.

Simplification of production methods. CARL NASKE. *Tonind. Ztg.*, **51** [13], 194–97 (1927).—N. traces the simplifications brought about by the introduction of automatic machinery in several of the industries. F.P.H.

Research work in engineering colleges. ANON. *J. Am. Inst. Elec. Eng.*, **46**, 222 (1927). (*C. A.*)

Elements and principles of industrial heating. E. DAMOUR. *Chal. et. Ind.*, **7**, 61, 145, 219, 459, 589, 705 (1926).—A course of 6 lessons on the principles underlying the working of industrial furnaces, with particular application to the glassmaking industry. (*Jour. Soc. Glass Tech.*)

Costing in earthenware works. F. DOBROVSKI. *Keram. Rund.*, **34**, 343, 377 (1926).—The necessity of costing is emphasized, and the principles of a costing system for earthenware are explained in general outline. The establishment of a card index system and its use in the various departments are dealt with in detail. (*Trans. Ceram. Soc.* [Eng.])

Training of ceramic personnel. ANON. *Tonind. Ztg.*, **50**, 278 (1926).—Preliminary training in a Trade School under State supervision under the instruction of men who have had practical experience should be followed by four terms at a Higher Technical School (Hochschule). This training should enable students to qualify for the diploma. (*Trans. Ceram. Soc.* [Eng.])

Glasslike synthetic resins. E. C. C. BALY. *Chem. Trade Jour.*, **79**, 618 (1926).—An account is given of an investigation into the properties of the synthetic glass "pollopas." This is not a competitor of glass; it begins to deteriorate at 200° and decomposes at 250°. It is non-inflammable, and can be heated to 150° in superheated steam, dropped into liquid air, and the process repeated 20 times without injury. (*Trans. Ceram. Soc.* [Eng.])

BOOKS

German Ceramics of the Present. KONRAD STRAUSS, Halle A. S. (1927) Wilh. Knapp. 44 pp. *Tonind. Ztg.*, **51** [32], 552–53 (1927). F.P.H.

Lead Poisoning in the Mining of Lead in Utah. A. L. MURRAY. U. S. Bureau of Mines, *Bull.* No. 389, Washington, 1927. Price 10c. H.H.S.

PATENT

Application of weather-proof coatings to objects of clay and similar materials by the cold method. L. KÖHLER. Ger., 423,637, May 12, 1923. Equal proportions by weight of magnesia, asbestos, and borax are finely powdered, thoroughly mixed, and

converted to "spreading" consistency with paraffin oil. The mixture is applied in the usual way, and the objects are dried in the air, or in a drying chamber at low temperatures. (*Trans. Ceram. Soc.* [Eng.])

Book Reviews

Clays, Their Occurrence, Properties, and Uses. H. RIES. 3d edition, revised and enlarged. John Wiley & Son Inc. Price $7.00. This third edition is a great improvement over the two preceding editions in style, completeness, and scope. Annotations and references bring up to date all that is known on origin, constitution, properties, varieties, and distribution of clays in North America. The author's exhaustive search of the literature is shown throughout the book. A good perspective and balance according to relative importance of the several topics is maintained throughout. Although not treated better than other subjects, the author's presentation of methods of testing is unusually well done. It is a valuable book to own as well as an excellent text and reference book. EDITOR

Defects in Glass. C. J. PEDDLE, with foreword by W. E. S. Turner. 230 pp., 44 illustrations. Glass Publications, Ltd., Talbot House, Arundel Street, Strand, London, W. C. 2. Price 8*s* 6*d*. A valuable contribution to the literature of glass technology, making for a more complete understanding of the greatest of all difficulties in glass manufacturing, defects in glass. A classification of defects is made in six divisions, according to the stage of production at which they appear, though some may appear at more than one stage. These include defects while molten, those apparent during the working of glas· those appearing during the annealing of glass, those which show up during the "afterworking" of glass, storage defects, and defects of glass during use. In the chapter on lack of homogeneity, types, causes of, prevention and removal of, and methods of testing for striae are discussed. Bubbles, seeds, etc., and stones are thoroughly discussed in separate chapters. Causes of devitrification taken up are the separation of solids from solutions, saturated and unsaturated, reaction between solvent and solute (dissolved solid), effect of supersaturation, and deposition caused by increase of temperature. Conditions governing devitrification are listed. Results of tests on seven series of glasses to trace the influence of silica upon devitrification are treated fully in one chapter. The influence of the "stabilizing" oxides of calcium, barium, aluminium, and lead was studied in test melts and results are discussed. Devitrification in the body of the glass and surface devitrification are the main subdivisions of the chapter on the influence of fluxing oxides upon devitrification. Miscellaneous defects during melting and working include scum and glass gall, opalescence, discoloration, streaky metal, watery metal, stiff metal, narrow working range, black specks in glass, molding defects, and "casing" defects. Faulty annealing is taken up under the subtopics of testing of annealing, annealing temperature, and effect of composition upon annealing temperature. The question of durability of glass, testing of durability, and effect of composition upon durability are taken up in the last chapter. The discussions throughout the book are in considerable detail and the style is such as to hold the reader's attention to the subject under discussion. The book is of value to all practical glass men as well as technologists. E.J.V.

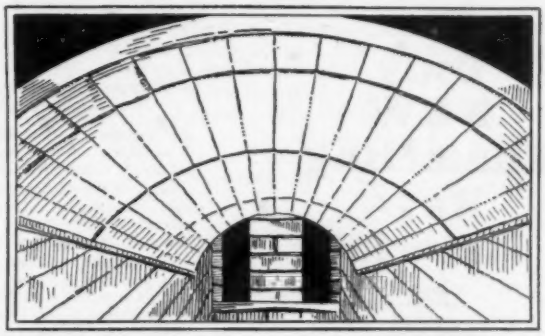
Early American Pottery and China. JOHN SPARGO. The Century Co. 393 pp. In the foreword the author rightly says that "this book is not in any sense a history of American pottery and china, though it is largely given to historical record." He aims merely to aid the amateur collector of American pottery and china by describing the ware of potteries and of potters whose products are distinctive. The book is made very readable by an easy recital of those historical high lights which give evidence of the credit due to individuals and to concerns. A chronological list is given of note-

worthy potters of interest to antique collectors and also a selection of marks. Mr. Spargo disclaims knowledge of pottery compositions and of pottery making. He might well disclaim knowledge on which to base scientific classification of pottery into "soft paste," "hard paste," "china," "porcelain, etc." His classification of glazes, seriously given, is actually funny. His first two chapters show woeful ignorance of the technical differences in pottery compositions and properties. He should not have attempted them. The remaining chapters of this book are a delightfully written history, full of frank acknowledgments of inability to identify unmarked ware notwithstanding their apparent composition, style, and properties. His historical accounts of firms are verified from documentary records. His bibliography of books on American history is selective of only those which have been found accurate. Fully and well illustrated to show the various types of designs, and decorations, this is a worth while book for the ceramic technologist as well as for the ceramic historian. It is full of inspiring recitals and descriptions. EDITOR

A Handbook of Scientific and Technical Societies and Institutions of United States and Canada. *Bull. National Research Council*, No. 58. Issued May 1927. Price $3.00 paper cover; $3.50 cloth cover. This is a ready guide to those scientific and technical societies and institutions which contribute knowledge or which support research through activities, publications, or funds. Organizations numbering 709 in United States; 74 in Canada, are listed. Addresses, history, membership, object, meetings, funds, and publications of each organization are given. EDITOR

Industrial Research Laboratories of the United States Including Consulting Research Laboratories. *Bull. Nat. Research Council*, No. 60. Issued July 1927. Compiled by C. J. West and W. Risher, 153 pp, price $1.00. This *Bulletin* is valuable to those who are making investigations. Names of 999 companies, number of persons employed by each in research and the character of research are given. Address list of directors of research, geographical distribution of laboratories and subject classification of laboratories are given. EDITOR

Directory of Commercial Testing and College Research Laboratories. Dept. Commerce Bureau of Standards, Miscellaneous publication No. 90. Issued April 1927. Price 15 cents. Supt. of Documents, Government Printing Office, Washington, D. C. This is a geographical distribution of laboratories and classification of commodities tested. EDITOR



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EDITORIAL

THE RÔLE OF THE CERAMIC PETROGRAPHER

A Brief Review of the Development of the Ceramic Petrography[1]

BY ALBERT B. PECK

Although this is a highly competitive and scientific age in industry and new facts count heavily, it is well to occasionally look back and briefly consider past accomplishments before looking into the future. One direction in which this may prove profitable is that of ceramic petrography. In this branch of ceramics, petrographic methods are being used more and more, until the point is rapidly being approached where no description can be considered complete without some reference to the microstructure of the ceramic body in question. A brief review of the development of this branch of ceramics may therefore be of general interest.

The real microscopic study of porcelain or other ceramic products depended originally, and still does to a large extent, upon the use of the petrographic or polarizing microscope. Although this type of microscope had existed for some time previously, its real usefulness began with the development of thin transparent rock sections in 1850. In that year Sorby showed how a rock fragment could be ground down and mounted between glass slides for preservation and study. About

[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Detroit, Mich., February, 1927. Received January 24, 1927.

twelve years elapsed, however, before the significance of this became apparent to petrographers, when in 1862 Zirkel began a systematic study of minerals in thin sections, in which he was joined by others.

Most of this work was done in Europe, especially in Germany. Nearly all of the first petrographic methods were developed there, especially under such famous petrographers as Zirkel, Rosenbusch, Becke, and others.

The development of the "bright line" method by Becke (1893) and of the method of inclined illumination by Schroeder van der Kolk (1900) in connection with mineral fragments immersed in oils of known refractive indices, gave a great impetus to the study of ceramic products because it allowed a rather accurate determination to be made of that fundamental property, the index of refraction, and also removed many limitations present when thin sections were used exclusively.

The history of ceramic petrography can be divided conveniently into three eras; first, one marked by scattered ineffectual attempts; second, a period of development of exact fundamental knowledge of silicates; third, the practical application of the results of the second stage.

First Era Ceramic petrography is comparatively young and may be considered to have had its beginning only fifty-four years ago (1873). In that year, Behrens observed small crystals in porcelain, the chemical properties (insolubility) of which he described. He did not definitely name the crystals but from his descriptions and in the light of our subsequent knowledge, there can be no doubt that they were the "sillimanite" with which we have later become so familiar. Hussak, in 1889, as a result of his observations of thin sections of porcelain, definitely suggested the presence of sillimanite in porcelains. In 1890, Vernadsky published the first chemical analyses of these crystals, which he had isolated from clay after heating it or from fired mixtures of alumina and silica. This marked a very important forward step because it enabled both the optical and chemical evidence to be tied up with a definite compound.

Behrens also pointed out that quartz was dissolved to a certain extent in the molten feldspar of the body but that kaolin was apparently more soluble than quartz, and that the sillimanite crystals resulted from devitrification.

On the whole, judging from actual results, the first period might be considered as comparatively unproductive, due to the small number of workers and to the lack of systematic studies, handicapped in turn by rather crude and limited methods. Nevertheless, it is important because of the realization that through petrography there was opened up a new way of attack upon ceramic processes and problems.

Second Era The second phase of development began about 1900, at which time Schroeder van der Kolk showed how the immersion method could be used in determining various optical constants of minerals. But a more potent influence was the fact that about 1901 the idea of a laboratory for the study of silicate mixtures was conceived. This resulted in the establishment of the Geophysical Laboratory at Washington in 1907, although work of this nature had been carried on for several years previously.

The period is primarily one in which a start was made in the development and discovery of fundamental facts and principles involved in silicate reactions. This marked a new era in ceramic microscopy, although it must be admitted that the effect of the work of the Geophysical Laboratory was neither felt nor realized until nearly ten or twelve years later. In the meantime, however, a large amount of valuable knowledge had been accumulated, awaiting the opportunity for its use.

It was in this period also that America showed the first tendencies toward leadership in research in pure science and applied ceramics, previously confined almost entirely to Europe.

Much of the credit for the strides made in these years must be given to the personnel of the Ceophysical Laboratory. Their early efforts were directed primarily toward the accumulation of fundamental geophysical data without reference to its industrial application, which to a large degree is still true. It is quite proper that this should remain so, since, from the standpoint of both equipment and past experience, its staff is better prepared to obtain such knowledge than any similar laboratory.

The method involved in this work is simple in its conception; namely, to combine physical-chemical methods with the use of the petrographic microscope in obtaining the phase relations of the components of a system. But while the basic idea is simple, the actual working out of the problem is frequently a long, tedious process, and involves difficulties which, to overcome, require experience gained from the past and the highest degree of ingenuity. While originally purely scientific in its aim, it has been found possible and profitable to translate this work in various ways into a practical application to ceramic industry. Thus, for example, we find close relationships between these systems and the composition of Portland cement, the behavior of silica brick in firing and in use, the identification and cause of stones in glass, and the study of the compounds of alumina and silica, which has culminated in the recent review of sillimanite and the discarding of the term "artificial sillimanite" in favor of mullite. It is frequently true that the results can not be carried over bodily into practical ceramics

without modification; nevertheless, the fundamental principle is still there, ready for use.

Meanwhile, Europe was not standing still, even though later events have shown that the period marked the beginning of the emancipation of America from the domination of Europe in ceramic research. Rapid progress was being made in the petrography of porcelain, Portland cement, silica brick, and other products. Thus, we find such names as Mellor, Plenske, Glasenapp, Zoellner, Endell, Rieke. Equally rapid progress was being made in America and we note the names of Day, Wright, Shepherd, Sosman, Fenner, Bowen, Morey, McCaughey, to mention only a few.

Third Era There is no sharp line of demarcation between the second and third periods. The latter appears to be a logical development out of the results of the preceding period. Research in pure science steadily increased and continues to do so at the present time, but simultaneously with it about 1910–1912, a change can be noted, which represents the beginning of the realization of the industrial importance of microscopic characteristics of ceramic bodies. This marks the third period. We find it expressed in the establishment of such work in connection with both research laboratories of large ceramic companies and government bureaus actually in touch with the industry. With this development the circle is practically complete; the university and research laboratory for pure science contribute information to those in contact with the practical problems, the bureau and the industrial research laboratory.

To realize the progress which America has made along these lines, one has only to note the frank manner in which Eitel[1] recently called attention to the high grade of silicate research being carried on in this country at present. Since that time Dr. Eitel has visited this country and judging from his enthusiasm and his praise of what he has seen, one must be convinced that great progress has been made.

That the principle of ceramic petrography as an aid in research is firmly established, can not be doubted. To cite but one specific instance of the part which the microscope has played in the development of a product, we are now making certain types of porcelain in which the mineral, andalusite, is one of the principal raw constituents. All studies of porcelains in the past had indicated that the better grades were characterized by a high content of sillimanite. It was natural, therefore, to attempt to increase the amount of this compound in the porcelain by introducing natural minerals of the same character. Unfortunately, however, these were not available; so it was necessary to develop an

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[1] *Keram. Rund.*, **30** [32], 1924.

artificial "sillimanite" calcine in place of the natural mineral. The microscope was freely employed in this work to follow the effects of various mixes and fluxes in causing crystalline growth in both the calcine and the body in which it was used. With the subsequent discovery of commercial deposits of andalusite, petrographic-microscopic methods were again used to follow through all stages of experimentation from the untreated ore, its grinding, mineralogical changes taking place during firing, to the grain size and character of the crystals formed in the finished product. The resulting ware surpassed the older porcelains in many ways, especially in mechanical strength and electrical resistance.

A sign of the times also is the increasing references in the literature, first, to minerals, both old and new, and their use in ceramic bodies, and second, to the microstructure of bodies and changes taking place during firing. This can not be considered as a strange phenomenon, because minerals, from the raw material to the finished product, are the bases of ceramic bodies. A review of the pages of the *Journal of the American Ceramic Society* alone during the past two years, shows no less than twenty-eight papers devoted wholly or in part to some phase of microstructure or of minerals, their firing behavior, effects of grain size, and so forth. Of these papers, fifteen, including four dealing with X-rays, appeared during 1925, and thirteen, including one dealing with X-rays, during 1926.

We are undoubtedly only on the threshold of ceramic research. What the future holds, no one knows, but it is certain that wider use will be made of petrographic methods, both in control and coordination in research. To cite a few possibilities, we shall give more attention toward the control of grain size in grinding; to the effect of time, temperature, and fluxes upon the grain size of the finished product; to the use, firing properties, and resulting microstructures of minerals new to the ceramic industry. And in all of this, the microscope will play its part.

At present we are entering a new era, that of the X-ray. What it will bring, again no one can predict with certainty. That it will be exceedingly useful, if intelligently used, there can be no doubt, for we have already had instances of its possible value in the controversy which has arisen around natural sillimanite, the so-called artificial sillimanite, and mullite.

Fundamental Importance of Microstructure

Regardless of the type of ware involved, the ceramist is fundamentally interested in the pyrochemical and pyrophysical changes which take place during firing. There are many ways in which these may be followed, among which is the use of petrographic-microscopic methods. These

changes may be very complicated, due to the large number of constituents. They may take place in a series of steps or simultaneously. In many cases the mineralogical structure of bodies is directly connected with these changes, because the properties and functions of the mineral constituents produced govern the behavior of the body during and after firing.

Chemical analysis is frequently quite useless in determining this, unless some knowledge is available concerning the manner in which the elements are combined; that is, the mineral constitution of the body. Furthermore, no essential change in chemical composition may occur during firing and yet great physical changes may take place, which are best determined microscopically. This, for example, is true in the firing of silica brick. It is largely the amount of quartz which has inverted to other forms of silica (tridymite and cristobalite) which determines whether or not the finished product will prove successful in use. Specific gravity determinations are useful here but microstructure also is important and can sometimes be determined more quickly than can a value for specific gravity.

Thus microstructure in one way or another is one of the fundamental characteristics of ceramics. It is probable that no ceramic body fails to undergo some change in microstructure when fired, although, to be sure, this often cannot be detected.

Purposes of Microscopic Examination

The purposes of or possibilities involved in petrographic examination of ceramic ware are not necessarily limited to the determination of pyrophysical and pyrochemical changes during firing. Among the various facts upon which a ceramic microscopist may throw light are not only the constituents present in a body and the changes which have taken place in them, but also the grain size, the form of development of the crystals or grains, their angularity, and many other matters. Furthermore, the actual microstructure developed in the body is important as is also the determination of critical points for the beginning of crystal growth or inversion points. Finally, it is one of the microscopist's duties to attempt to construct the facts into a true history of the body or into an interpretation of what changes have taken place in it.

One of the most useful functions of ceramic petrography is to offer suggestions for further lines of study. In order to do this intelligently, it should be unnecessary to point out that the petrographer should be furnished with a complete history of what has been done, the compositions used, and other pertinent facts, and also what result is desired.

While the use of the microscope alone will sometimes solve a problem, the inference should not be drawn that the microscope is always

sufficient in itself; in fact, its usefulness is frequently as a supplementary agent to other methods of analysis. For example, specific gravity and the chemical composition of a material would not seem to be closely related but the microscope may throw much light upon these points. Its use will save much time and give an accurate idea of the purity of basic materials. Irregularities in composition may be quickly determined and the cause corrected. Take as an example the use of andalusite, cyanite, and sillimanite in porcelain. Recalculated analyses of the raw material may show much more Al_2SiO_5 present than is indicated by the microscopic examination, and material which may obviously be of rather poor grade from the petrographic standpoint may still yield a rather high specific gravity and a good analysis. Re-examination may show the cause of both to be due to the presence of free Al_2O_3 in the form of corundum, which is not an infrequent associate of the minerals of the sillimanite group. Corundum possesses a rather high specific gravity and therefore tends to raise that of the whole ore. Furthermore, in the recalculated analysis, this excess Al_2O_3 neutralizes the excess quartz which is likely to be present in almost any ceramic material and thus the total Al_2SiO_5 may be high, even in ore which appears poor upon casual inspection.

Moreover, the ceramic petrographer occupies a unique position between the practical and the purely scientific man, and he must attempt to unite the two viewpoints. The manufacturer or technical man should realize that the petrographer is not usually a trained ceramist, but that he is, by training, fundamentally a pure scientist. He has been compelled to acquire what knowledge of ceramics he may possess upon the basis of his general training, especially in physical chemistry. On the other hand, the petrographer has at his command much valuable information in the way of principles and analogies derived from the study of rocks and artificial melts. These principles may be translated into ceramic terms and applied in a general way to ceramic problems, for the study of the petrography of igneous rocks borders very closely upon that of ceramic products. The fundamental principles may not be taken over bodily but may need modification because of the element of time, the presence of mineralizers and other factors in rocks, which are not generally present in the production of ceramic ware.

Some Factors Influencing Microstructure

It is not the present purpose to discuss all factors influencing the microstructure of a body but simply to point out one or two examples from different sources. Just as there are many factors affecting the behavior of a body, similarly in the field of ceramic petrography there are many factors influencing the resulting microstructure. Thus, the

minerals used in a body have a decided effect upon its properties and structure. Some are less stable or less refractory than others. For example, it was not surprising to the mineralogist that the minerals andalusite, cyanite, and sillimanite, all having the same chemical composition, should behave differently when heated. The long known facts that they crystallized in crystals of different symmetry and form and that they showed variation in resistance to solution by acids, were plain indications of differences in structure. The study of these minerals in rocks had also indicated that they were formed under unlike conditions. They might therefore be expected to act differently when heated. Again, mention may also be made that some minerals are much more resistant toward the solvent effect of fluxes in a body than are others, thus producing decidedly different structures.

Variations in chemical composition and increases in the temperature of firing have very marked effects upon the microstructure.

The effect of small amounts of active fluxes such as CaO, MgO, and BaO, may produce very pronounced results in microstructure and in maturity, as shown by Riddle.

The grain size of the material composing the body is also very important (Riddle having shown that finer grinding lowered maturity) having an effect similar to the addition of more feldspar.

In many cases, the factor of time is also apparent in the final microstructure. This is true in porcelains where crystal growth will proceed at lower than usual temperatures if sufficient time is given. Another example of the same type is the oxidation of silicon carbide at temperatures far below the points where such action ordinarily takes place.

The foregoing represent but a few of the possible factors to be considered. If the body is simple, perhaps only one factor will be of importance; if complicated, it may be necessary to consider several factors in order to arrive at a true interpretation.

Petrographer as an Interpreter

The ceramic petrographer must not only be a fact-finder but, perhaps of even greater importance, he must also act as an interpreter. Ability to interpret is often more important than ability to observe and is based largely upon experience, clear, logical thought, and knowledge of the most recent information, as well as upon training in fundamental physics, chemistry, and mineralogy, making use of the well known principles of petrography. With the necessary preparation it is quite possible for nearly anyone to become proficient in making the required observations and determinations of the constituents. Experience and individual ingenuity may aid in surmounting particular obstacles.

Teaching Ceramic Petrography

Finally, I desire to call attention to the fact that ceramic schools in general appear to be falling behind in the field of microstructure, both in its teaching and in research. Perhaps this is due to an inability to interest the mineralogist or petrographer in ceramics, or vice versa. Nevertheless, the fact remains that the greater part of the progress along these lines is being made in the laboratories of government or other research bureaus, in those of large commercial plants, or in some universities which do not have ceramic schools. It is gratifying to note, however, that this phase of ceramic training is being given more attention in recent revisions of the curricula of some of our universities.

While it may not be possible or even desirable for the ceramic curriculum to offer a course in petrography, owing to numerous prerequisites, some lectures upon the aims of petrographic methods in ceramics could certainly be included. The primary object of such a course would not be the knowledge obtained, but it would serve to give the students a basis for a more intelligent attitude toward cooperation with the petrographer.

Petrography and ceramics are both border line sciences. Both are fundamentally based upon the principles of chemistry, physics, and mineralogy, and problems in the two fields are more nearly akin than ceramists have yet realized. Ceramic petrography will probably always be the field of a specialist and, except in the case of a few large laboratories, the work will probably be carried on through consultation. Success would be proportional to the completeness of understanding between the petrographer and the ceramist, which should be greatly enhanced by a few lectures similar to those mentioned.

MINERALOGICAL LABORATORY
UNIVERSITY OF MICHIGAN

PAPERS AND DISCUSSIONS

CONCERNING NEW PROBLEMS IN THE PRODUCTION OF COMMERCIAL GLASSES[1]

Mechanical Homogeneizing and the Correct Heat Treatment History

By F. Eckert

ABSTRACT

Problems caused to arise by use of machine methods are greater uniformity in the molten glass and greater demands on the effective performance of the tank. Methods for producing homogeneous glass and defects encountered are discussed.

Introduction

Machine methods in the production of glass have caused new problems which were unknown with the hand methods. The machine demands greater uniformity in the molten glass because with it the individual equalization in the hands of the workman is lacking. It places greater demands on the effective performance of the tank as a result of the great quantity of glass required by a single machine unit.

More uniform glass and more effective tank performance have been sought by means of a suitable type of tank construction. This in turn has resulted in a struggle for tank blocks having greater slagging resistance. The builders of machines and tanks have not given as much consideration to the nature of glass with machine production as they must now give during the formation stage.

With hand gathering, homogeneity was of essential interest only insofar as it was evident to the eye. Hand means were used to hold coarse impurities back from the outlet. Such inhomogeneities as were due to streams of glass having different temperatures were overcome by more uniform heating and by long standing in large working tanks.

A uniform reheating of the glass to the working temperature does not promote homogeneity and involves the danger of devitrification.

Requisite with Machine Working

The first problem is to work the glass from the beginning of its formation under the most uniform conditions possible and with an ever increasing homogeneity in the working chamber. By homogeneity I mean a much higher degree of uniformity than has been customary in technical glasses and equal to that which heretofore has been required only in optical glasses.

Homogeneous glass in this sense shows neither striae nor bands, both of which are due to differential heating or to portions of the melt having different ages.

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., February, 1927. (Glass Division.)

Producing Homogeneity

The means of producing homogeneous glass are very simple and self-evident. They must merely be used in the right place, in correct sequence, and to the proper extent.

One begins with a thoroughly mixed batch having favorable range of particle sizes. This glass batch is then melted without the more fusible parts running off and without segregation. It is a grievous error to think of stirring up the batch while melting. Shirring prior to complete melting causes the glass to fine in the hotter portions of the furnace. Homogeneizing by mechanical stirring at one or two suitable points should be done only after the glass batch is completely melted. After this the chemically and physically homogeneous glass should proceed to the working process as rapidly as possible under uniform cooling. Technically this task is comparatively simple and is very advantageous from the standpoint of heat economy.

Uniform Heat History Important

The second thing of practical importance is that all the glass coming to the working process must have a like heat history. One-sided heating of the furnace, flowing of the glass in streams, and cleaving of the glass to the walls and bottom prevent the entire glass batch having a like heat history. A suitable form of tank is required and it should be subdivided into several separate compartments each with appropriate methods for supplying the heat. But most important of all it is necessary to prevent temperature variation in the tank due to radiation losses.

Effect of Excess Temperature on Glass Quality

It has become apparent that quality of glassware often is deteriorated by exposure of the batch to excessive temperatures while melting. For some unexplained reason excessive temperatures make the glass brittle; this cannot be corrected by subsequent cooling of the tank nor by annealing. This brittleness can, to be sure, be due to different aging at high temperatures, gross inhomogeneities, etc.

Brittleness of the resulting ware limits the use of very high temperatures during the glass-melting. Recognition of this is all the more important since higher temperatures are most favorable for heat transfer during melting. Brittleness of the ware has been observed more often since the science of firing and methods of transferring heat to the melting glass are better known.

For a considerable time these ideas have applied and have been confirmed thoroughly by experiments on sundry types of glass. Before a final conclusion concerning them can be made, further exact experi-

mental proofs will have to be obtained, particularly under those conditions where the strength of the glass is influenced by the history of its heat treatment.

TECHNISCHE HOCHSCHULE,
BERLIN, GERMANY

HISTORY AND IMPROVEMENT OF FURNACE BARS[1]

BY J. C. WEAVER

Until recently there was probably less advancement in the burning department than in any other part of the enamel shop. Practically all ware was burned on common iron bars and points.

In order to fire ware on common iron, it was necessary to cover the points with clay to prevent scaling. Even this did not entirely eliminate the trouble and a large amount of ware was lost by scales falling upon the pieces during the burning operation.

A few years ago it was proved that by using a bar made of nickel chrome alloy, all scaling troubles were eliminated and also that it was unnecessary to sharpen points so often.

The first bars were made of pure nickel chrome. It was found however that there was no corrosion on these bars and hence there was a great tendency for enamels to adhere to the points, thus causing considerable trouble. It was then found that putting iron into the metal would produce just enough corrosion to practically prevent the sticking of the enamel to the points and at the same time not enough to cause scaling to the extent of spoiling the ware.

By using alloy metal it has been possible to further improve production in the furnace.

Hanging racks and double deckers have been developed to the point where the amount of ware being burned today would have been unbelievable a few years ago. In cast iron it is not uncommon to see a thousand pounds go into the furnace on one load. Some stove plants are producing as high as 15,000 pounds of finished ware in 24 hours.

Enamelers have been able, by hanging sheets, to increase production from three to forty times. One sheet steel plant, having formerly used five furnaces, is now able to do more work on three furnaces by hanging ware and thereby shut down two of the furnaces. The saving in this particular case was tremendous.

[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Detroit, Mich., February, 1927. (Enamel Division.)

ACTIVITIES OF THE SOCIETY

1928 ANNUAL MEETING

American Ceramic Society

February 5 to 11

Hotel Ambassador, Atlantic City, N. J.

Affairs for the largest and best Meeting are rapidly shaping up. Divisional meetings are being arranged and soon the entire plan will be complete.

Drying The National Brick Manufacturers Association will meet concurrently, alternating sessions with the Heavy Clay Product Division. Douglas Stevens, secretary of the N. B. M. A. is anticipating a fine program and good attendance. Professors C. W. Parmelee and R. K. Hursh with their associates and the N. B. M. A. Committee on Research have a great deal of fundamental and applied data on drying, obtained in laboratory and plants, which will be of great value.

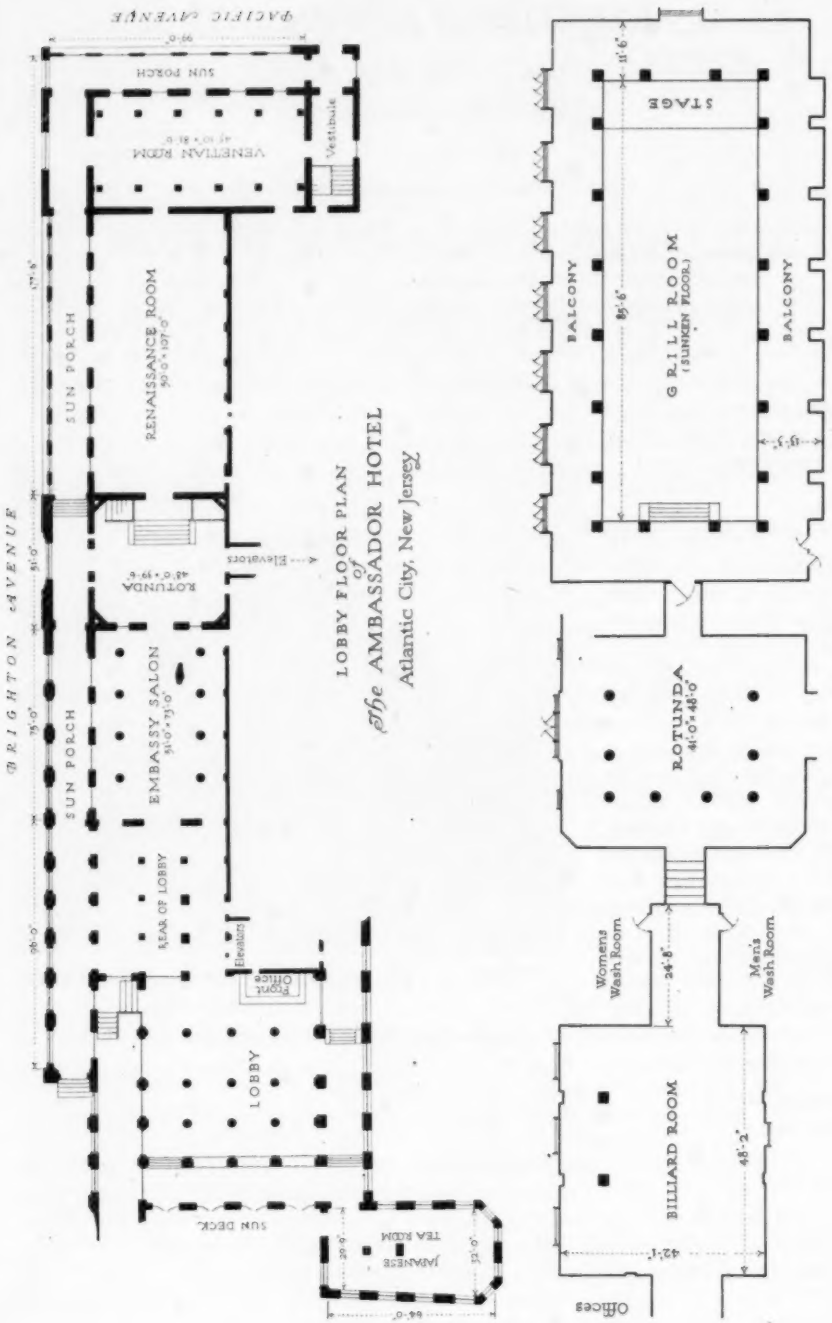
Clay Gathering Professors George A. Bole and H. E. Nold of the Ohio Ceramic Industries Association have now spent ten months, and will continue through the fall, in the study of methods of clay gathering and mining. Their object is to reduce costs and hazards and to increase yield values. They have many excellent data drawings, and actual facts together with suggestions for improvements. All who have data on employed operating methods and all who have new or novel methods in mind or practice are requested by Professors Bole and Nold to take part in this one-half day session on mining.

FIG. 1.—Exterior of Hotel Ambassador.

Division Meetings The several Division program committees are hard at work and the programs are taking shape. There will be the usual seven simultaneous meetings of the Divisions.

Exhibits Edward Kraus of Chambers Bros., Philadelphia, for the N. B. M. A. and Ercill C. Hill of Conkling Armstrong Terra Cotta Co., Philadelphia, are the heads of the committee on exhibits. They will have as their collaborators, Mrs. M. G. Westfelt, R. F. Ferguson, L. Squier, Leslie Brown, and three others to be appointed by the Enamel, Glass, and Heavy Clay Products Divisions, respectively.

There is to be no charge for space. The only expense will be incidental expenses for services which each exhibitor will secure from the hotel.



FIGS. 2, 3—Floor plans of the Hotel Ambassador.

The exhibits will include machinery, equipment, materials, and products. If the number and character of the exhibits warrant it, the Committee will provide stalls and easels, and distribute the costs.

Those who intend to exhibit machinery should communicate with Edward Kraus, Chambers Bros., Philadelphia. Those who wish to exhibit materials and products should notify Ercill C. Hill, Conkling Armstrong Terra Cotta Co., Wissahickon St., and Juniata Ave., Philadelphia. Exhibit blanks and shipping instructions will be sent on request.

Plant Trips J. M. Gilfillan of the Trumball Electric Co., Trenton, N. J., Pottery Division, has been appointed by D. Parry Forst, chairman of Meeting Committee of the New Jersey Clay Workers Association, to serve as leader in arranging plant trips.

Excursions by groups will leave Atlantic City Thursday morning. The secretaries of the Divisions will serve under Mr. Gilfillan as plant trip Committee. They are: Art, Marion Fosdick, New York School of Clay-Working, Alfred, N. Y.; Enamel,

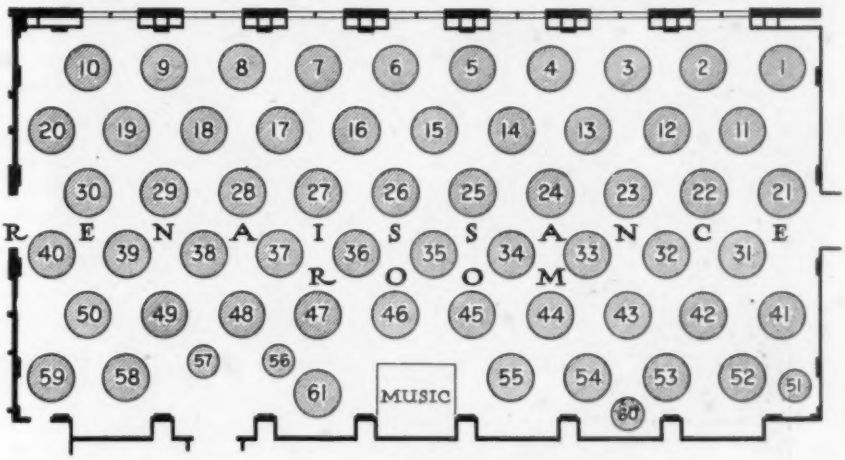


FIG. 4.—Floor plan of the Renaissance Room.

H. G. Wolfram, Porcelain Enamel Manufacturing Co., Baltimore, Md.; Glass, A. N. Finn, National Bureau of Standards, Washington, D. C.; Heavy Clay Products, H. R. Straight, Adel Clay Products Co., Adel, Iowa; Refractories, E. H. Van Schoick, Chicago Retort and Fire Brick Co., Ottawa, Ill.; Terra Cotta, J. R. Bowman, Midland Terra Cotta Co., Cicero, Ill.; White Wares, R. F. Sherwood, Pass and Seymour, Inc., Solvay, N. Y.

An interesting and economical plant itinerary through New Jersey, Maryland, and western Pennsylvania will be arranged including meals and hotel reservations for Thursday and Friday nights.

Entertainment The committee appointed by the New Jersey Clay Workers Association to serve as hosts and to make arrangements consists of D. Parry Forst, chairman, Robertson Art Tile Co., Morrisville, Pa.; "Jerry" A. Williams, Mitchell Bissell Co., Trenton, N. J.; R. L. Clare, Federal Terra Cotta Co., Woodbridge, N. J.;

Francis W. Dinsmore, Imperial Porcelain Works, Trenton, N. J.; E. V. Eskesen, N. J. Terra Cotta Co., New York City; Leslie Brown, Lenox, Inc., Trenton, N. J.; Professor George H. Brown, Rutgers College, New Brunswick, N. J.

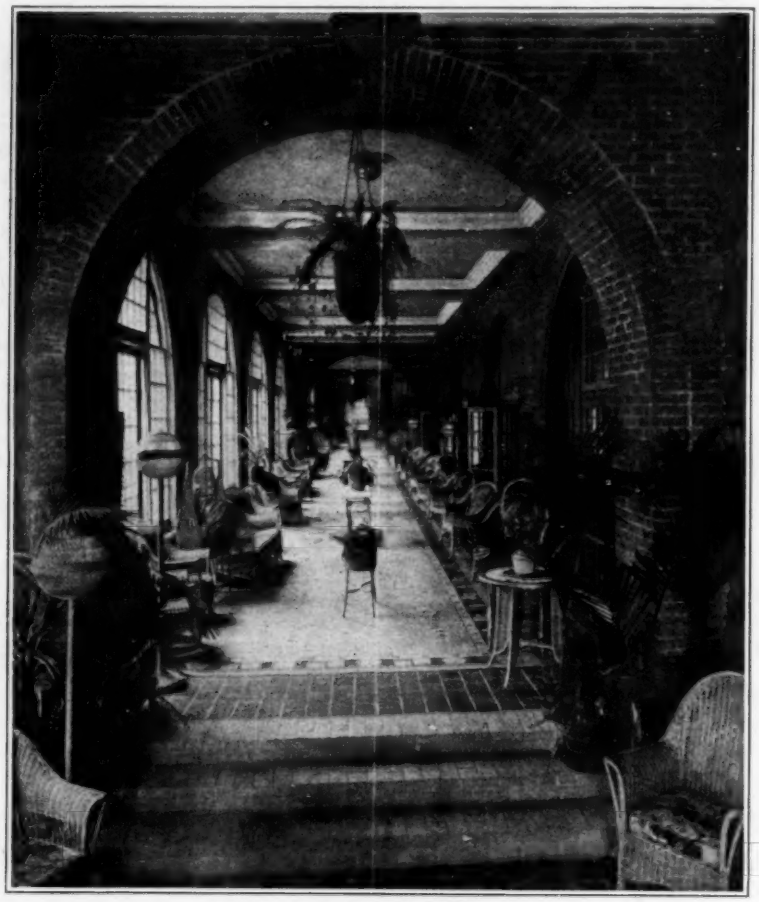


FIG. 5.—Solarium Exhibit Hall.

H. D. Carbary and E. T. Lawless, managers of the Hotel Ambassador, have already arranged wonderful and unusual entertainment features. The program is as follows:

Sunday	Registration and President's reception Symphony Concert, orchestra and soloists Dancing	
Monday	9:30 A. M. 2:30–5:30 P. M. 8:30 P. M.	General Session Division meetings Dinner Dance and Cabaret
Tuesday	9:30 A. M.–12:30 P. M. 12:30–5:30 P. M. 8:30–10:00 P. M.	Division Meetings Division Meetings Water Carnival

	9:30 A. M.–12:30 P. M.	Division Meetings
Wednesday	2:30–5:30 P. M.	General Meeting
	7:30 P. M.	Banquet

The Ambassador agrees to furnish the concert on Sunday evening in the main lobby, consisting of orchestral selections and vocal numbers, to furnish a dance orchestra for Monday night, to put on a water carnival Tuesday night, and to furnish the orchestra for the banquet Wednesday night.

The program committee for the technical sessions consists of General Secretary Ross C. Purdy, chairman ex-officio; Art, Myrtle M. French; Enamel, W. V. Knowles; Glass, C. D. Spencer; Heavy Clay, G. A. Bole; Refractories, C. F. Geiger; Terra Cotta, H. E. Davis; White Wares, R. F. Sherwood.

Hotel Rates There are to be no other meetings or conventions in the Ambassador while these meetings are being held. The room rates for one person will be $5, $6, $7, $8, $9, and $10 per day; for two persons $8, $10, $11, and $12 per day or $4, $5, $5.50, and $6 per person per day. All rooms are large, beautifully furnished, and outside.

Those who anticipate attending these meetings should make room reservations direct with E. T. Lawless, resident manager of the Ambassador. Groups desiring suites or series of rooms should arrange for them early, if choice is desired.

FIG. 6.—D. Parry Forst.

Excursion Railroad Rates Delegates to either the N. B. M. A. or AMERICAN CERAMIC SOCIETY Meeting will have the usual one and one-half (1½) return ticket fare on certificate basis for the purpose of attending the meetings. The certificates will be issued only in the name of AMERICAN CERAMIC SOCIETY, but procurable by all who attend the meetings of either association.

CERAMISTS' TOUR ABROAD

May 19 to July 5, 1928

Invited guests of the ceramic industries of all Europe! That is the status of all ceramic manufacturers. Europe is opening her arms with the hospitality characteristic of the people, to receive the boatload of American ceramists arriving at Havre, May 28.

Letters from our hosts in France, Germany, Czechoslovakia, Holland, and England express in most ardent terms, the joy with which they look forward to our coming. They are planning the lists of important and enjoyable places to visit, with the same care as you plan the entertainments for a guest invited to your home.

Leon Yeatman of Paris writes in part,

We shall of course be very glad to meet our American colleagues and I should suggest to arrange a banquet on one of the evenings to which we could invite the American ambassador and a representative of the French government. I also suppose that our American friends would like to devote two or three days to sight-seeing in Paris.

He goes on then to outline an interesting itinerary for three days in towns outside of Paris where most of the ceramic industries are carried on. This is to include the Sevrés Porcelaine Works, the quarries and tile works of Beauvais, and a glass factory near Paris, interspersed with motor and rail trips, lunches, and a banquet. M. Yeatman also wishes to know if there will be any who wish to see special kinds of ceramic plants; if so, he will make special arrangements for these visits as many of the French manufacturers do not, as a rule, open their doors to either domestic or foreign visitors.

FIG. 1.—Walter Butterworth, President of the Society of Glass Technology.

A most interesting letter from Amsterdam assures us that the Holland society is holding a special meeting in September for the purpose of discussing plans for our entertainment during our two-days stay in that city.

The German Ceramic Society is choosing a committee to make all the arrangements for the three days spent in Berlin. In one of the letters we are told that ceramics does not include glass and enamel in Germany, but representatives of these industries are coöperating with the Society to make things as complete as possible. They ask for a list of the types of plants which we would be most interested in, for the probable number of guests they will be privileged to entertain, and our feeling toward a convention of German and American men interested in the same type of work, at which addresses would be made by some on both sides. They are awaiting our reply, after which they will be set out to make as elaborate plans as possible for our reception.

Dr. R. Barta, general secretary of the Czechoslovak Ceramic Society, is very enthusiastic in welcoming the Americans to his country, and adds that he is "very ready to assist in every possible way as regards the three days which are to be spent in Czechoslovakia. The matter will be discussed at the next meeting of the Committee .... which will take place in the autumn."

Dr. J. W. Mellor, Secretary of the Ceramic Society of England, and Professor W. E. S. Turner, Secretary of the Society of Glass Technology, are doing their utmost to make the ten days spent in England a most profitable and enjoyable visit. They have already submitted tentative itineraries for our approval, asking us to suggest any change we may desire.

From these statements one can well imagine how much Europe is anticipating the coming of the American ceramists and the endless amount of preparation that is going forward to repay one in every possible way for the time and money spent on this elaborate trip.

The men of the Morriss Service, managers of the tour, are pushing their end of the work very rapidly, so that the entire plan may be laid before the tour members at the very earliest possible date. Contracts have been made with the European hotels which will house the guests. The traveling cases which will be furnished free to each of the members are being made stronger and better than the type usually supplied tourists.

Europe is sparing nothing to entertain *you* in the most elaborate fashion. You can not afford to miss an opportunity that may never come to you again. Factories will be open to you as a member of this tour, which will never be open to you as an individual American citizen; welcomes will be extended you which you may never receive at another

time; and best of all, you will be among hundreds of others whose ambitions and tastes resemble your own. One large American family is going to Europe for vacation and education. You do not want to be left behind.

Ross C. Purdy, general secretary of the AMERICAN CERAMIC SOCIETY, and P. B. G. Morriss, manager of the tour, have already sailed for Europe to make final arrangements for the guests next spring.

The ship accomodations which have been secured for the tour are those known as "cabin"; that is equivalent to first class on the fastest and most expensive ships on the Atlantic. It is the best the ship has to offer with no restrictions, at a reasonable price, but on a slightly slower ship. For those who wish to sail earlier or remain in Europe after the sailing date the regular price of $145, less 5%, will be the credit allowance.

The cost of the tour is $900.00, including all fares, hotel accomodations, and meals. Passport fee and personal expenses are the only extra costs to the tourists.

May 19 to July 5 are the dates. There will be a week's trip through Scotland for those who wish an extended tour. The boat will sail from Liverpool July 7, arriving in New York July 16.

NEW MEMBERS RECEIVED FROM AUGUST 1 TO SEPTEMBER 1

CORPORATION

Standard Clay Products Co. Inc., Slidell, La. Ralph H. Weston, Superintendent.

PERSONAL

Howard G. Seldon, 225 Fifth Avenue, New York City. Manufacturing Agent.

STUDENT

Roland F. Hodder, California Institute of Technology, Glendale, Calif.

Membership Workers' Record

	CORPORATION		PERSONAL
Office	1	Thomas B. McCann	1

STUDENT

Hobert R. Goodrich 1

Total 3

PERSONAL NOTES OF MEMBERS OF THE SOCIETY

H. R. Borland has moved from Thurber, Texas to 408 Oak St., Danville, Ill.

A. D. Busch formerly of St. Louis, Mo., is now located at 6941 West 30th St., Berwyn, Ill.

E. F. Creevy, Jr., of the University of Illinois is employed with the Standard Sanitary Mfg. Co., P.O. Box 1, Richmond, Calif.

Charles M. Dodd has accepted a position as instructor in the Ceramic Department, Missouri School of Mines, Rolla, Mo., Mr. Dodd formerly was employed with the Robinson Clay Products Co., Akron, Ohio.

Worth S. Elton of Angola, N. Y. is in Heyburn, Idaho at the present time.

Charles W. Ferguson who has been located at the plant of the Gurney Foundry Co., St. Laurent, Quebec, Can., has removed to Baltimore, Md., where he is associated with the Porcelain Enamel & Mfg. Co.

Henry G. Fisk who has been conducting research studies at the Columbus Station, U. S. Bureau of Standards, received his doctorate degree from Ohio State University in June and has accepted a position with Gladding McBean & Co., 621 Hope St., Los Angeles, Calif.

Alex. E. Fitzgerald, University of Illinois student is working for the Chicago Pottery Co., Chicago, Illinois.

P. A. Handke, assistant superintendent of the Purington Paving Brick Co., Galesburg, Illinois, has moved to 421 E. Third St., N., Newton, Iowa.

R. F. Geller has accepted a position with The Abrasive Company, Bridesbury, Philadelphia, Pa., to be effective on October 1, 1927. Mr. Geller has been conducting ceramic research work at the U. S. Bureau of Standards since 1918 and since 1923 has been chief of the Refractories Section of the Ceramic Division.

Isaac Kahn of the Wheatley Pottery, Cincinnati, Ohio has accepted a position with the Cambridge Tile Company, Covington, Ky.

Harold S. Nash has recently become affiliated with the Ceramic Department, University of Cincinnati, Cincinnati, Ohio. Mr. Nash previously was Assistant Manager of the Foskett Co., Inc., Port Jervis, N. J.

Elmer H. Ockerman has left the employ of the Alhambra Kilns, Inc., and is now employed in the research department of the Vitrefrax Co., Los Angeles, Calif.

Frederick H. Rhead who has been director of research for the American Encaustic Tiling Co., Zanesville, Ohio, has removed to Newell, W. Va., where he will conduct research and direct the art department of the Homer Laughlin China Co.

Rossman Corporation has announced the acquisition of the business and assets of the following companies: Robert Rossman Co., Beaver Falls, Art Tile Co., Perth Amboy Tile Works, The Old Bridge Enameled Brick and Tile Co. The general office is located in the Reeves Bldg., Beaver Falls, Pa., and there are branch offices in New York, Chicago, and San Francisco. The officers of the Rossman Corporation are: F. W. Walker, Chairman of the Board, August Staudt, Vice Chairman of the Board; F. W. Walker, Jr., President; George L. Esp, Sales Manager; L. S. Hawkins, Vice President in charge of Sales Engineering; F. S. Hunt, Vice President, in charge of Production; C. F. Brand, Treasurer; A. J. Pumpurs, Vice President in charge of Plant Engineering; G. E. Sladek, Vice President, in charge of Research; William Waldorf, Secretary; Division Managers, William Waldorf, New York; J. A. D'Eath, Chicago; E. L. Bradley, San Francisco.

Frank C. Schultz is now ceramic engineer and day superintendent of the Darlington plant of Fiske & Co., Inc., Darlington, Pa.

Walter Schulz has recently transferred from Baltimore to the Granite City, Illinois plant of the National Enameling and Stamping Co.

E. A. Slagle has removed from Amarillo, Texas, to 1012 Hamilton Ave., Trenton, N. J.

R. T. Stull who has been located at Macon, Ga. for several years has removed to Washington, D.C. where he is associated with the U. S. Bureau of Standards.

Ray T. Watkins has resigned his position with the Canadian Research Council, Ottawa, Can. and is now connected with the Ceramic Division, U. S. Tariff Commission, Washington, D. C.

MEETING FOR ORGANIZING A CERAMIC COUNCIL

On September 21 and 22 President Hood of the AMERICAN CERAMIC SOCIETY, called a meeting of manufacturers of ceramic products to consider organizing a ceramic council, the purposes and character of which are suggested in the attached memorandum.

This proposed Council is not "another one", but a federation of interests already existing; it is a practical means of employing to the fullest extent those agencies which now are operating and also those which should be engaged on ceramic investigations. It does not call for money assessments or frequent meeting attendance by manufacturing executives.

Councils similar to the one proposed have been organized by ceramic manufacturers in foreign countries. The National Research Council has rendered in general science such notable service that several of America's largest industrial companies, knowing the economic returns which accrue to them, have endowed it with large sums and annuities. The idea of a Council has a proven value.

Ceramic manufacturing in America will be in a better position to meet competition from abroad and from substitute products when a ceramic council has gotten under way.

Plan of the Ceramic Council

Purpose The purpose of the Ceramic Council would be (1) to provide means for correlation and initiation by ceramic manufacturers of America in research, standards, and data; (2) to provide a personnel for collaborating with universities in investigations of problems in fundamental and applied science and in engineering relating to the development, production and use of ceramic products; (3) to take leadership in advisory relations with federal bureaus, state organizations, and trade associations; (4) to promote industrial fellowship; and (5) to provide a central place for the clearing of fundamental and applied information on art, science, technology, and engineering, and for listing available means of obtaining such information.

Organization The Ceramic Council could be an organization of ceramic manufacturing. equipment, and supply companies with its own officers and articles of organization and be self-determining in all its affiliations and activities.

Affiliate Relations with American Ceramic Society The AMERICAN CERAMIC SOCIETY is a well-going and substantial coöperative enterprise, incorporated for nonprofit under Ohio laws, by and for ceramic artists, scientists, and engineers to promote ceramic research and education, and to collect and make record of information on the science and technology problems in ceramic ware production. Its members have a record of thirty years of increasing effectiveness in the tasks they have coöperatively undertaken.

The reason why the AMERICAN CERAMIC SOCIETY does not accomplish all that is proposed to be accomplished by the Ceramic Council is (1) the SOCIETY is not universally supported and has no constitutional relations or connections with the ceramic trade associations; hence, is not the accredited agent for the ceramic industries of America n matters relating to product researches and investigations by public and semi-public nstitutions; (2) it is mostly a federation of industrial employees who are without self-determination regarding attendance at Committee Meetings and in giving financial support.

To serve as is proposed for the Ceramic Council, the SOCIETY would have to have the financial and personal support and participation of the ceramic works' managers and executives as firm representatives. To what extent this would upset the control and character of organization now operating is so problematical as to suggest the separate and distinct organization to be known as the Ceramic Council.

Council Membership The AMERICAN CERAMIC SOCIETY now has 18 corporation members, firms which are giving $25 annually in support of the work of the individual members.

It is suggested that the corporations continue their membership in the SOCIETY, but have their own organization (the Council) in close affiliation with the SOCIETY but separately officered; each member of the Council is to be, in fact, an active member of the SOCIETY with full privileges of voice and vote; the Council will take over the direction and the function of the Committees on research, standards, and data, leaving the SOCIETY members to contine coöperating in collecting and recording of information and serving as affiliate members of the Council Committees

In lieu of the $7950 which the SOCIETY now annually receives from corporation members, it is suggested that the Council pay in support of the SOCIETY the sum of

$6000 annually. Thus the SOCIETY would be transferring to the Council the sum of $1950 which now it is receiving from the corporation members.

The Council would employ a chairman, a librarian, and office assistants, and the SOCIETY would provide without cost to the Council the required office and library facilities, including fixtures and equipment.

Financial Statement On a conservative basis of 600 corporations at $50 annual dues, the Council's income would be $30,000.

A suggestive budget could be—

Chairman salary	$7500.00
Librarian	2400.00
Office assistants	1600.00
Committee and chairman traveling expenses	3500.00
Membership in AMERICAN CERAMIC SOCIETY	6000.00
Fellowships	9000.00

Affiliation with Trade Associations Even if the Council membership should be that of individual firm membership, the members could act collectively on all matters through their respective associations. In other words, the Council could have its Industrial Divisions much the same as the SOCIETY has had so successfully for the past ten years.

Benefits Accruing The ceramic industries, perforce of their combined support through the Council, would be in position through their chairman of committees (1) to have voice in the expenditure of the $125,000 annually spent on ceramic research at the Federal Bureau of Standards; (2) to divert the prison brick yards from competitive manufacturing to research; (3) to obtain state appropriations for research in university engineering experiments stations; (4) to divert more of the geological survey appropriations to investigations of ceramic materials; (5) to secure engagements and provide ceramic problems for study by graduate pupils in universities; (6) to furnish information regarding personnel and laboratory facilities to the end that association fellowships may be placed where the work can most effectively be done; (7) to advise in the making of plant applications of the results obtained; and (8) in many ways and means, make possible for the ceramic industries to get more out of the monies which they annually pay through taxation in support of the federal and state institutions for research and education.

By virtue of the affiliation between the Council and the SOCIETY, the Council members would have all the privileges of active members of the SOCIETY and receive, without additional cost, the SOCIETY's monthly *Journal* and other publications.

The advantage to the trade associations would be in (1) the more direct affiliation and control of the AMERICAN CERAMIC SOCIETY; (2) having an experienced and organized advisory council of their own on all questions pertaining to technical investigations; (3) have mutually supported and concerted action in securing their just share of the public monies expended for investigations; and (4) engaging research laboratories to work on fundamental and applied ceramic problems.

Products which are competitive with ceramic products are the subject of study and development in all universities and Federal laboratories and for the most part without direct cost to the industries because the manufacturers of these competitive products are united in one organization for no other purpose than to secure the employment of the largest possible number of agencies on the development and the improving of their product; and this is being done quite largely to the exclusion of work on ceramics. This was the case in Ohio until this year, although collegiate ceramic education and research in America was begun at Ohio State University. Our public institutions will respond only when the ceramic industries of all sorts, clay, glass and glass enamel, are united to ask it of them.

PROGRESS REPORT OF RESEARCH COMMITTEE: ENAMEL DIVISION

By R. R. Danielson[1]

Previous to the Annual Meeting of the Metallurgical Advisory Committee of the Bureau of Standards, the writer was requested to attend a conference of representatives of the Metallurgy and Ceramic Divisions at the Bureau to discuss recent results of the work on blistering of cast iron for enameling purposes and the advisability of continuing the research.

Those present were: Messrs. D. L. Gillett, Saeger, Jordan and Krynitsky, representing the Metallurgy Division of the Bureau; Messrs. P. H. Bates and W. N. Harrison, representing the Ceramic Division of the Bureau; and Messrs. R. R. Danielson and H.G. Wolfram representing the Enamel Division.

The Bureau has been continuing this work for the past three years and has accumulated, at a cost probably ten times the amount furnished by the Enamel Division, a large mass of data bearing on this problem. Unfortunately, however, the data have not enabled the Bureau to point conclusively to a definite cause for blistering in the iron. It was thought, when this problem was initiated that the so-called northern irons would produce blistering while the southern irons would not, but this has not been found to be true in all cases, since some of the northern irons furnished the Bureau by the Committee have been found to be satisfactory. No single factor such as remelting, chemical composition, gas content, etc., has been determined as being a direct cause of blistering and indeed the big difficulty, from the standpoint of the Metallurgical Division, in solving the problem has been the inability to point to a single iron which could definitely be called a blistering iron under all conditions, or one which could be called a nonblistering iron under all conditions.

Recent studies of the Ceramic Division, however, on the firing range of the standard enamels which were furnished them a year ago have indicated at least two lots of iron which seem to have these characteristics. That is, one particular lot has been found to have a rather wide firing range in which no blistering (or very slight blistering) developed while another definite lot of castings has shown a very short range. These have been designated as "good" and "poor" irons respectively, which seems to be in accord with our general conception of nonblistering and blistering irons.

On this basis the following program for future work was agreed upon.

I. Preparation of Test Plates

A sufficient number of the 3- by 6-inch plates(approximately 720 plates of each iron) will be cast of an iron which shows a narrow range and of one which shows a wide range of conditions within which the ground coat can be fired to produce unblistered pieces, when fired in the electric furnace and in the gas-fired furnace of the Enamel Section of the Bureau. These two irons are to show as much difference in blistering behavior as the two particular heats referred to above (and which were fired only in the electric furnace due to the lack of sufficient test pieces). An attempt will be made to handle all the duplicate heats alike in the melting so as to secure the same composition and microstructure.

II. Checking Behavior of Irons

The behavior of these irons when coated with the standard high fire ground coat and white enamel now used by the Bureau, will be checked through the application of a low fire high lead "single coat" enamel to castings from these same heats.

The results obtained at the Bureau will then be checked by sending samples of the two lots of iron and prepared lots of the two types of enamels to two outside laboratories

[1] Chairman of Research Committee, Enamel Division.

for duplication of the tests. This will be done in the Research Laboratories of the Porcelain Enamel and Mfg. Company, and the Metal and Thermit Corporation, which are reasonably close to the Bureau and are equipped with electric and gas-fired furnaces of sufficient size and other necessary equipment to duplicate the Bureau's tests under definitely controlled conditions.

The combined results of the above tests will show either (a) there is a definite and consistent difference in the tendency of the two irons to produce blisters, or (b) there is no definite and consistent difference. If there is no difference, then no metallurgical problem will be considered to exist, and a report to that effect will be issued in which certain partial remedies such as range-finding and preheating will be suggested. If there is a definite difference, a metallurgical problem exists and this may be exhaustively studied if funds permit. The plans for the metallurgical study are as shown here. This may not be sufficiently exhaustive, but the Bureau will follow the problem as far as possible or as may be advisable.

III. Program for Further Study

If a definite difference between the two irons is established, the following lines of attack (metallurgical, chemical, and ceramic) will be begun at once. The specific phases to be studied will include the following:

Heat Absorption Thermocouples will be used to determine whether or not there is any difference in the black body conditions of the two irons as indicated by their rate of heat absorption under identical conditions. Thickness of castings and thickness of ground coat will be varied in these tests.

Microstructure Exhaustive microscopic study of the two irons, including especially graphite formation, will be made.

Porosity of Irons Differences in porosity of the two irons will be studied. One proposed method for doing this is to measure the relative gas absorption of the iron specimens.

Preheating Preheating will be studied to determine the manner in which it effects improvement of results. This phase of the work is directly connected with the work the Bureau has done recently in preheating the ground coats as applied to the iron and previous to the actual firing, as differentiated from annealing of the castings now the practice in some plants. The Bureau's work indicates that the firing range of a "poor" iron may be greatly extended by this treatment. At present, the importance of the findings is not in the commercial application of the treatment, but rather in the light it may throw on the solution of the general problem of blistering.

The effects of the following practices will be studied in their relation to blistering: (*a*) annealing of uncoated casting as compared with preheating with enamel applied; (*b*) preheating of enamel and subsequent cooling as compared with preheating of enamel and placing in maturing furnace while hot; (*c*) preheating of enamel for various times at different temperatures.

Moisture The part that moisture plays in the production of blisters will be studied. The test of preheating and subsequent cooling should throw some light on this question. In addition to that, tests will be made grinding the frit with a non-aqueous liquid. Both raw clay and calcined clay will be used in these tests. The results will be compared with those obtained with slips containing water, made up in the regular way.

Ferroxyl Test The relation between degree of perviousness of the first coat and blistering will be studied by submitting first coated samples of both irons to the ferroxyl test, and attempting to correlate the results with the blistering tendencies of the irons.

This completes the program as arranged at the conference. The Metallurgical Division is now preparing the two lots of iron required for the further studies and if they

are successful in duplicating the "good" and "poor" irons referred to, the enameling tests at the Bureau and the other coöperating laboratories should be completed at an early date. Provided these results are positive, I believe we can conservatively expect some very definite conclusions from the Bureau for the next meeting of the Enamel Division, as the Bureau is very much interested in completing the study as soon as possible.

This Report is being sent to all members of the Research Committee. If definite "good" and "poor" irons are obtained in the work now under way, it will probably be worth while publishing the program of work in one of the forthcoming *Journals*, but for the present it is not being distributed generally.

It is my intention to send Progress Reports of the work to the Committee as they may be justified, but in the meantime I shall be glad to have the reaction of the members to the program which has been planned.

REPORT OF GLASS DIVISION, STANDARDS COMMITTEE, AMERICAN CERAMIC SOCIETY

The Standards Committee of the Glass Division is following a program laid out two years ago. It has issued a Standard Sand-Soda-Lime Glass for analysis, collected methods of analysis and results obtained by use of these methods. These results and methods have been the basis for the "Method of Analysis of Sand-Soda-Lime Glass" adopted by the division at the February meeting at Detroit.

The same procedure was followed for the analysis of glass-sand for the iron content only and a standard method for this determination was likewise adopted by the Division.

Through the efforts of the Committee, the Bureau of Standards has taken on the task of preparing and distributing the standard samples of soda-lime glass, dolomite limestone, glass-sand, lead glass, and opal glass. The Committee will make up standard methods for these different materials and will submit them to the Division for approval or rejection at the Annual Meeting. A. R. PAYNE, Chairman

METHOD FOR COMPLETE SAND ANALYSIS[1]

Preparation of the Sample

The sample may be a well-mixed unground portion or it may be ground in an agate mortar.

Solution of the Sample

Weigh out a 10 g sample and place it in a platinum dish of suitable size (250 cc is recommended). Moisten the sample with water and add 10 cc of concentrated sulphuric acid. Fill the platinum dish two-thirds full with concentrated hydrofluoric acid and evaporate on the sand bath, or, if so desired, on the hot plate with an asbestos board beneath, to a volume of about 50 cc. Care must be taken to avoid mechanical losses. Examine the contents of the dish and if complete solution of the sample has not taken place add more hydrofluoric acid and evaporate again. When complete solution of the sample has been accomplished evaporate to copious fumes of sulphuric acid and add one or two drops of fuming nitric acid to oxidize any organic matter. Cool the solution, dilute to about 100 cc, filter, and transfer any residue left in the platinum dish to the filter. Wash the filter 5 times with hot water, place in a covered platinum crucible, dry, and ignite until the filter paper has entirely burned off. Cool the crucible, add about 2 g of sodium carbonate and fuse over a Meker burner or its equivalent. Cool the crucible, dissolve the melt with dilute hydrochloric acid and hot water in a small covered beaker.

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[1] An article under a similar title appeared in the July *Bulletin*. There are several important changes and additions in this, due to discussion and correspondence after the first article was published. This is the final and corrected Report.

If a residue still remains after this treatment, filter into the main solution and wash 4 times with hot water. Dry and ignite the filter in a covered platinum crucible and fuse with one gram of potassium pyrosulphate. Dissolve the melt in dilute hydrochloric acid and hot water and add to the main solution. Evaporate the total solution to a small volume and transfer to a platinum dish. Add 5 cc of concentrated hydrofluoric acid, evaporate to fumes of sulphuric acid, cool, wash down the sides of the dish with hot water, and again evaporate. Cool, add 50 cc of water and allow to stand 5 minutes. If the solution is not clear, filter and wash the residue 6 times with hot water.

R_2O_3

Heat the filtrate from "Solution of the Sample" to boiling, add 2 or 3 drops of methyl-red indicator and then dilute ammonium hydroxide drop by drop to a yellow end point. Boil from 1 to 2 minutes and filter immediately. Transfer the contents of the dish or beaker to the filter with hot 2% neutral ammonium chloride and wash 5 times with this solution. Dissolve the precipitate in the minimum amount of hot hydrochloric acid (1:10), receiving the washings in the original beaker in which the precipitation was made. Wash the filter thoroughly with hot water and reserve. Precipitate again as before with the aid of macerated filter paper if desired to aid in filtering. Transfer the precipitate quantitatively to a filter with hot neutral ammonium chloride (2%) or ammonium nitrate and wash 6 times with either of these solutions. Place the reserved paper and the precipitate and paper in a previously ignited platinum crucible weighed with cover, dry, and ignite under good oxidizing conditions at approximately 1100°C, finally covered. Cool in a desiccator over a good desiccant, never calcium chloride, and quickly weigh the covered crucible. Repeat the ignition until a constant weight of "R_2O_3" is obtained.

CaO

Combine the filtrates from the two "R_2O_3" precipitations, make slightly acid with dilute hydrochloric acid, and evaporate to a volume of about 150 cc. Add a slight excess of dilute ammonium hydroxide and heat to boiling. Add slowly and with constant stirring 10 cc of a 4% solution of ammonium oxalate and boil 5 minutes. Let stand on the steam bath for 4 hours or preferably over night. Transfer the precipitate to a small filter and wash with ten 5 cc portions of cool 1% ammonium oxalate solution. Place in an ignited platinum crucible weighed with cover, dry, and ignite at approximately 1000°C. Cool over a good desiccant, never over calcium chloride, and quickly weigh the covered crucible. Repeat the ignition until constant weight is obtained.

MgO

Make the filtrate from the oxalate precipitation distinctly acid with hydrochloric acid and add 0.5 g of diammonium phosphate $(NH_4)_2$ (HPO_4). Evaporate to 150 cc and cool. Add ammonium hydroxide slowly to a slight excess. Stir vigorously until precipitation begins. After several minutes add ammonium hydroxide (specific gravity, 0.90), to make one-ninth by volume. Let stand over night. Filter on a previously ignited and weighed Gooch crucible or on filter paper if so desired. Wash with 5% by volume ammonium hydroxide 5 times, dry, and ignite gently. Finally ignite to constant weight at approximately 1100°C as magnesium pyrophosphate, $Mg_2P_2O_7$.

Ignition Loss

Ignite 5 g of sample at approximately 1100°C in an ignited and weighed covered platinum crucible to constant weight. Report the loss in weight of the sample as per cent ignition loss.

The Determination of Iron as Fe_2O_3

Weigh a 10 g sample of the sand into a platinum dish of 150 cc capacity. It is not necessary to grind the sand. Moisten the sample with water and add 2 cc of concentrated sulphuric acid. Mix thoroughly by shaking the dish. Hydrofluoric acid (C.P. 48%) is now added until a few drops no longer produce any reaction. This reaction is not

violent unless the sand is ground. Fill the dish two-thirds full with hydrofluoric acid, place on the sand bath or hot plate, and evaporate. The sand becomes flocculent and may completely dissolve. In the latter case, the evaporation is carried to sulphuric acid fumes, rapidly at first, then carefully to avoid loss by spattering. In case the solution is not complete, carry the evaporation down half way, then refill the dish with hydrofluoric acid and evaporate to dryness. Ignite the dish containing the residue for a few minutes at approximately 1000°C to drive off all sulphuric acid and destroy any organic matter present. Cool the dish containing the residue and add 25 cc of hydrochloric acid (1:1), cover with a watch glass, heat to boiling, and filter into a 500 cc beaker. Wash the filter paper 4 times with hot water. Return the paper to the dish and ignite. Make a quick fusion with sodium carbonate (2 grams 5 minutes). Dissolve the melt in dilute hydrochloric acid (1:1), and add to the main solution, disregarding any silica that may have been carried over. Neutralize the main solution with ammonium hydroxide and then add enough dilute sulphuric acid to have a slight acidity to litmus paper. Thoroughly saturate the solution with hydrogen sulphide, digest for one-half hour and filter. Wash the filter thoroughly with hot water. Boil off the excess hydrogen sulphide from the filtrate and add a few drops of concentrated nitric acid. Heat the solution to boiling and add a slight excess of ammonium hydroxide. Boil from 1 to 2 minutes and filter quantitatively. Redissolve the precipitate the hot dilute (1:4) hydrochloric acid and again precipitate with ammonia. Filter, wash 4 times with hot water, and dissolve the precipitate from the paper with hot hydrochloric acid (1:1) receiving the solution in a 500 cc Erlenmeyer flask. Wash the filter thoroughly with hot water. Add (1:1) hydrochloric acid and concentrated hydrochloric acid equal to the volume of the wash water used to bring the volume up to 200 cc. Cover with a watch glass and heat to boiling. Cool the neck of the flask with a stream of cold water. Reduce the iron with stannous chloride (minimum number of drops). Adjust the titration head, insert the buret tip, and titrate with standard potassium dichromate solution, while recording the potential by means of a Roberts Electrometric Titration Apparatus. From the potential-titration curve ascertain the number of cubic centimeters of potassium dichromate solution required by the iron chloride in the solution. Calculate the per cent of total iron as Fe_2O_3. Report as Fe_2O_3.

A blank is run on the reagents used and the blank subtracted from the titration.

NOTE: Where the very highest accuracy for the iron determination is not desired, the sulphuric acid treatment and removal of the platinum metals with hydrogen sulphide may be omitted.

Determination of Titania and Zirconia

Fuse the ignited and weighed R_2O_3 residue with 1–2 g of potassium pyrosulphate and take up the melt in 30 cc of dilute sulphuric acid (1:9).

(A) Determination of Titania

Transfer the solution to a Nessler comparison tube, rinse with a very little of the acid, add 3 cc of fresh hydrogen peroxide and dilute with the acid to 50 cc. In another tube dissolve an equal amount of pyrosulphate in the dilute acid, add 3 cc of the peroxide and dilute with acid to the same volume. To the comparison tube add a standard solution of titanium sulphate, $Ti(SO_4)_2$, until the colors in the two tubes are exactly the same when the solutions are thoroughly mixed. The amount of titanium oxide added, divided by the total volume of the solution represents the amount of titania per cubic centimeter of the unknown solution. This value multiplied by 50 represents the amount of titanium oxide in the sample taken for analysis. It is not likely that a glass-sand will contain so much titanium that the color in 50 cc of a solution obtained from a 1 g sample will be too strong for colorimetric comparison.

The standard solution of titanium sulphate can be prepared from titanium oxide of known purity or from potassium titanium fluoride K_2TiF_6. The former can be fused

with potassium pyrosulphate, the melt dissolved in dilute sulphuric acid, and the solution diluted to the desired volume with the same acid. If the fluoride is used, purify the salt by crystallization from hot water in platinum and dry the crystals. Treat the calculated weight of the dried crystals with sulphuric acid in platinum, evaporate to fumes, cool the solution, and wash the walls of the vessel with water. Repeat the evaporation and washing twice to make sure that all fluorine is expelled. Cool the solution, prepare a dilute sulphuric acid solution (1:9) of the desired volume, and determine its titer by precipitation with ammonia and final ignition to TiO_2.

(B) Determination of Zirconia

To determine zirconia add 5.0 g of diammonium phosphate $(NH_4)_2HPO_4$, to the solution that was used for the determination of titania and which should still contain hydrogen peroxide and approximately 10% of sulphuric acid by volume. Cover and allow to stand over night at a temperature of 40–50°C. Hydrogen peroxide must be present in excess at all times. If a precipitate appears, filter the solution and wash the paper and precipitate with a cold 5% solution of ammonium nitrate. Dry the paper and precipitate in a weighed platinum crucible, cautiously burn off the carbon, and finally heat at approximately 1000°C. Cool and weigh as ZrP_2O_7 which contains 46.3% of zirconium oxide.

Al_2O_3

Alumina is determined by subtracting from the total R_2O_3 the percentages found for Fe_2O_3, TiO_2, and ZrO_2.

SiO_2

Silica is determined by difference by subtracting the percentages of R_2O_3, CaO, MgO, and ignition loss, from 100.

Blank

Run a blank determination on the reagents using exactly the same amounts of chemicals as in the original analysis. Subtract any impurities found from the amounts found in the analysis of the sand.

NEWS FROM THE LOCAL SECTIONS

Baltimore-Washington Section

The Baltimore-Washington Section is planning to have its four regular meetings in October, December, February, and April, meeting alternately in Washington, D. C. and Baltimore, Md., on the first Saturday of these months.

Papers will be presented at these meetings on subjects pertaining to those branches of the ceramic industries in which its members are most interested, and it is expected that the season will be an active one in the discussion of vital ceramic problems.

C. B. McComas, Secretary

California Section

The California Section is planning a meeting for the latter part of September on machinery in the clay plant. T. S. Curtis will present a paper on microphotographs in natural color.

F. A. McCann Secretary

Chicago Section

The members of the Chicago Section held a meeting at the Nordic Country Club, northwest of Chicago, on September 1, 1927. Following luncheon a short business session was held and the remainder of the afternoon was spent in playing golf.

Six men were nominated to serve on the Advisory Committee of the University of Illinois as follows: J. C. Fry, Coonley Mfg. Co., Chicago, Ill.; William Levis, Illinois Glass Co., Alton, Ill.; F. W. Butterworth, Western Brick Co., Danville, Ill.; William Schlake, Illinois Brick Co., Chicago, Ill.; F. J. Clifford, Chicago Pottery Co., Chicago,

Ill.; J. A. DeCelle, Chicago Hardware Foundry Co., North Chicago, Ill.; and H. J. Lucas, Northwestern Terra Cotta, Chicago, Ill.

F. A. GUIGNON

St. Louis Section

Charles C. Lake, Secretary of the St. Louis Section writes that plans are being completed for the Fall and Winter Meetings of the Section. An extensive membership campaign will be promoted commencing with the first Fall Meeting. Announcement of this Meeting will be made later.

NOTES AND NEWS

Romance Marks Life of Scott Turner

The story of Mr. Turner's life since his graduation from Lansing High school, the University of Michigan, and the Michigan College of Mines, has in it all the romance, adventure, and travel of which almost all men dream but few realize. His work has carried him from the Arctic circle, to the jungles of Africa, and from desolate trading post to the capitals of the world. He was on the Lusitania when it was sunk by German submarines and was under the fire of the Zeppelin bombers when the Germans made their first air raids on England.

Scott Turner is a native of Michigan; his forefathers came from England and Scotland long ago, and have been American citizens for many generations. In 1902, at the age of 21, he was graduated from the University of Michigan, with an A.B. degree. His major study was geology and throughout his course he was closely associated with I. C. Russell, professor of geology, and a member of the United States Geological Survey. He then went to the Michigan College of Mines at Houghton where he took B. S. and E. M. degrees.

On leaving Houghton in 1904, he bought railroad transportation to the limit of his ready cash, which landed him in Tombstone, Ariz., where he was miner, millman in an experimental plant, and assistant engineer for the Development Company of America. At the end of nine months he moved to the Black hills of South Dakota, thence to Montana, Oregon, California, and Nevada. During this period he worked as miner, millman, or engineer, as the opportunity offered, finally settling for some months in Leadville, Col., where he was millman and outside foreman. Thence he drifted into some of the old gold camps in Gunnison county, Colorado, but was shortly called east and sent to examine mines in Panama. On completion of these examinations, he remained in charge of operations for several months.

FIG. 1.—Scott Turner.

Worked Underground

On returning to the States he went to Nevada as examining engineer and as millman in various properties. From Idaho he was called to San Francisco to become assistant to T. A. Rickard who then owned and edited the *Mining & Scientific Press.*

He joined F. W. Bradley's staff of engineers, and was first sent to Tacoma where he represented the Alaska Treadwell group, and the Bunker Hill & Sullivan at the

smelter. In 1908 Bradley loaned Turner to T. A. Rickard, and together they traveled through the Yukon and Alaska. When Rickard returned to San Francisco, Turner stayed at Nome for the balance of the open season on the engineering staff of the Wild Goose Mining & Trading company catching the last boat from Nome.

In January, 1909, Turner was called to Mammoth, Shasta county, Calif., as chief assistant to the mining geologist of the U. S. Smelting Refining & Mining company and a year later he was appointed geologist, remaining another year in that capacity.

Goes to Africa

In January, 1911, Turner struck out for northern Africa, wandered through Spain for some weeks, and next turned up in Cornwall where he spent a short time in the tin districts.

He was engaged to make an examination of the coal fields in Spitzbergen, and iron properties in North Norway. As the result of this work, at the end of 1911, he was engaged by Frederick Ayer and John M. Longyear of Boston, as general manager for the Arctic Coal company, and for Ayer & Longyear in Europe, and the Arctic Steamship Co., Ltd.

During the next five years he devoted himself entirely to this work, opening, developing, and equipping the coal fields, getting new mines into production, and getting together a fleet of vessels for this Arctic service.

On Lusitania

Spitzbergen was at that time terra mulius, belonging to no nation, and under the jurisdiction of no power. When the war came, operating became increasingly difficult, and Turner decided the business should be sold to European operators. In the spring of 1915 he was in negotiation with the Russian cabinet, which wanted the mines to supply coal to the Russian railway on the Murman coast. He was due to reach Petrograd late in May to continue these negotiations, and was on his way there on the Lusitania when she was torpedoed and sunk on May 7, 1915.

Turner then returned to Norway, and opened negotiations with a strong financial group there, which resulted in all the company's holdings being sold to the Norwegians, in the spring of 1916.

Turner immediately started for South America on mine-examination work for London banking interests. He spent the next two years in Peru, Chile, and Bolivia, but when the United States entered the war he returned and signed on with the navy for four years, receiving a commission as lieutenant, senior grade.

In January, 1919, he was placed on the inactive list, and at once went to Canada as chief field engineer for The Mining Corporation of Canada, Ltd., and its various subsidiaries. A few months later he was promoted to the position of consulting engineer to the corporation. The interests of the Corporation, over which he had complete technical control, include large silver mines in Ontario, with a record of production exceeding sixty million ounces, a very extensive copper, zinc, gold, and silver mine in Manitoba, a gold mine in Western Russia, and valuable mining properties or interests in Quebec, British Columbia, Mexico, Central and South America, and many other foreign countries.

Mr. Turner took the oath of office as Director of the Bureau of Mines Nov. 16, 1925, and after arranging his private and professional engagements so as to bring them to a close at the end of that year, he assumed the duties of Director on Jan. 1, 1926, and has since continued them. Various changes have gradually been brought about in the Bureau, including the establishment of an Economics Branch, for the purpose of studying the economic problems of the mineral industry, and the creation of a Health and Safety Branch, through which is administered all matters pertaining to the health and

safety of men in and around mines, quarries, oil and gas fields, etc. The Bureau as now constituted consists of four branches, each specializing in its own particular line.

Certain shifts in personnel have been arranged, with the idea of more effectively and more economically conducting Bureau affairs, and research work in the Technologic and other Branches has been featured. The Bureau has just completed, June 30, 1927, a most successful year, and the prospects seem bright for a record year in 1928.

CERAMIC SCHOOL NOTES

Georgia School of Technology

Prospects for the coming year at Georgia School of Technology are excellent. In all probability there will be thirty students enrolled in the Ceramic Department.

During the past year a number of improvements have been made to increase the efficiency of the Department and also to take care of an enlarged student body. A spray booth and accessories have been added and the kilns have been equipped with differential draft gages. The Department has also supplied itself with equipment for the purpose of making plant tests with special reference to drying and firing economy.

The Department is continuing its policy of investigations leading to mineral development. The field work in the study of Georgia clays, conducted in coöperation with the State Geological Survey, will be completed in about two months. The remainder of the year will be devoted to testing in the Ceramic Department laboratories.

A. V. HENRY, Director, Department of Ceramics

Louisiana State University

The Department of Ceramic Engineering at the Louisiana State University will open this fall with approximately eight students, three juniors, three sophomores, and two freshmen.

This department is continuing its work on a clay survey of the State of Louisiana for the State Department of Conservation. The northern half of the state has been prospected and the samples sent in to the laboratory at Baton Rouge. Part of the work of students is the testing of this clay and determining its value.

The laboratory is equipped for work in heavy clay products, enameling, pottery, and glass work. J. W. WHITTEMORE, Head of Department of Ceramic Engineering

New York State School of Clay-Working and Ceramics

With the coming semester, the entire Ceramic Building of the New York State School of Clay-Working and Ceramics at Alfred, N. Y., will be devoted to the increasingly large classes in ceramic engineering. The continued growth of the school has made it necessary to occupy one of the buildings formerly used by the School of Agriculture. This building, which will accommodate the Department of Applied Art, has been newly equipped and the teaching staff increased. The present faculty is:

Charles F. Binns, Director; Professor of Ceramic Technology
Murray J. Rice, Professor of Chemistry
Frank C. Westendick, Professor of Ceramic Engineering
Clarence W. Merritt, Assistant Professor of Ceramics
Marion L. Fosdick, Professor of Ceramic Art
Clara K. Nelson, Professor of Drawing and Design
Charles M. Harder, Assistant Professor of Applied Art

North Carolina State College

The Department of Ceramic Engineering at North Carolina State College, Raleigh, expects a registration of from twelve to fifteen freshmen for the next college year making a total registration of about 40 in the four classes.

There was a considerable reduction in the number of students during the previous college year due to elimination and the transfer of a number of students to the course in Industrial Management. In this course the student is required to minor in one of the engineering departments. All students who were desirous of entering the business or sales ends of the ceramic industries were transferred to the Industrial Management Department.

Eight or ten seniors are expected to return and the prospects are that all will graduate.

No additions have been made to the teaching force.

A number of pieces of new equipment have been added to the laboratory including a battery of blungers, two crushers, six ball mills, and a cross-breaking machine.

The Silicate Research Laboratory presented to the department by the North Carolina Clayworkers Association is being installed and it is hoped will be completed during the Fall term.

The registration in the correspondence courses in Ceramic Engineering has climbed steadily during the past summer, an especially large number of students taking up work in enamels. Approximately 300 students are now registered for these courses, Ohio, Illinois, and California heading the list with over twenty-five each.

A. F. GREAVES-WALKER, Director of Department of Ceramic Engineering

University of Saskatchewan

The Ceramic School of the University of Saskatchewan is anticipating a very busy year in the matter of research work on the Saskatchewan white firing clays. During the present summer five men have been at work on this problem and expect to have material ready for publication by midwinter.

One of the school's recent graduates, J. W. Craig, has been appointed to a position with the National Research Council, of Canada, and is at present in Ottawa entering upon his new duties. W. G. WORCESTER, Professor of Ceramic Engineering

University of Toronto

Although it is too early for the ceramic department of the University of Toronto to figure registration totals, six men have spent the summer in the local ceramic plants and intend to enroll in the Ceramic Department this fall. Four will be in the third year and two in the second year. One student writes that he expects to enroll in the first year, so the total should be about seven.

ROBERT J. MONTGOMERY, Assistant Professor of Ceramics

NORTH CAROLINA BUFF AND GRAY FACE BRICK MANUFACTURED FOR THE FIRST TIME

With the commencement of operation of the new $50,000 addition to the plant of the Moland-Drysdale Corporation at Etowah, N. C. on August 15, the first buff and gray face brick to be made in North Carolina were turned out. The production of buffs and grays at this plant followed the survey and investigation of the buff firing clays of the French Broad valley made several years ago by A. F. Greaves-Walker of the Department of Ceramic Engineering at North Carolina State College and the coöperative research carried on by the Company and department in the Ceramic laboratories at the College and plant during the past year.

The new plant has a capacity of 50,000 brick per day and both texture and smooth face are being produced. As buff brick imported principally from Ohio and Pennsylvania have been extensively used in North Carolina and the Southeast, a good market is assured. The Company will continue to manufacture its regular line of reds and flashed colors.

Bruce Drysdale, president of the North Carolina Clayworkers Association, is Vice President and General Manager of the Company and L. R. Whitaker, a recent graduate in Ceramic Engineering at N. C. State College is Ceramic Engineer. Mr. Whitaker designed and had charge of the erection of the new addition.

FIRST NATIONAL FUELS MEETING
ST. LOUIS, MO.

October 10–13, 1927

Arranged for

All Engineers and Organizations Interested in the Use and Conservation of Fuels

A meeting of exceptional importance to American engineers and executives and to the general public has been arranged by the Fuels Division of the American Society of Mechanical Engineers. The meeting should appeal to any one interested in any phase of the production, transportation, or application of fuels.

Despite the millions of dollars that are spent annually for fuels, it is hard to realize the little thought that is given to their efficient application. Not only is little attention paid to conservation of fuels, but small consideration is given to the tremendous losses due to imperfect combustion, the damage done to property, and the menace to health. This has been brought out by prominent physicians and also by the survey of the Citizens' Smoke Abatement League of St. Louis. The latter organization is now engaged in the most comprehensive Smoke Abatement Campaign in the country. St. Louis this year will doubtless be the center of fuels and smoke abatement activities.

Men of international reputation, who are authorities in their fields, will speak at this meeting. All papers will be preprinted and presented in abstract form, giving plenty of time for discussion.

Almost every engineer, every manufacturer, and every executive is interested in some phase of fuels work. Although the meeting was arranged by the Fuels Division of the A.S.M.E., it is for all engineers and executives. The meeting has already been sponsored by many interested organizations.

LIST OF PUBLICATIONS OF THE AMERICAN REFRACTORIES INSTITUTE

Together with a List of Reprints on File in the Secretary's Office

The American Refractories Institute has issued a list of publications which can be obtained from its office. The sheets have been cut and punched to fit a technical binder to make them convenient for frequent reference. As long as the supply lasts requests will be taken care of in the order of their receipt. The price of the papers is given. Reprints that are designated "for reference only" may be borrowed from the office. Communications may be addressed to The American Refractories Institute, 2202 Oliver Bldg., Pittsburgh, Pa., Miss Dorothy A. Texter, Secretary.

Technologic Papers

Tech. Paper No. 1, June 15, 1926, "A Study of Tests for Refractories, with Special Reference to Spalling Tests," by Stuart M. Phelps. 50c per copy.

Tech. Paper No. 2, October, 1926, "The Load Test for Fire Clay Refractories," by M. C. Booze. 25c per copy.

Tech. Paper No. 3, August, 1927, "Plastic Refractories," by Stuart M. Phelps. 50c per copy.

Monthly Technical Bulletins

Bulletin No. 1, July, 1926, "A Résumé of the Activities of the Research Division of the American Refractories Institute during the Year Ended June 30, 1926, by Stuart M. Phelps.

Bulletin No. 2, August, 1926, "The Testing Division of the American Refractories Institute," by Stuart M. Phelps.

Bulletin No. 3, September, 1926, "Tentative Specifications Formulated by the American Refractories Institute."

Bulletin No. 4, October, 1926, "The Technical Program of the Fourth Semi-Annual Meeting of the American Refractories Institute," by Stuart M. Phelps. (Supply Exhausted)

Bulletin No. 5, November, 1926, "The Laboratory Testing of Refractories: A General Discussion," by R. F. Geller. (Supply Exhausted)

Bulletin No. 6, December, 1926, "Nomenclature for Refractories," by Stuart M. Phelps.

Bulletin No. 7, January, 1927, "Notes on Mullite Refractories," by Stuart M. Phelps.

Bulletin No. 8, February, 1927, "Refractories for the Malleable Cast Iron Foundry," by C. E. Bales.

Bulletin No. 9, March, 1927, "Studies of the Effects of Chlorine, Sulphur Dioxide and Carbon Monoxide upon Various Refractories," by Stuart M. Phelps.

Bulletin No. 10, April, 1927, "Shrinkage of Fire Clay Refractories," by M. C. Booze.

Bulletin No. 11, May, 1927, "The Effect of Water Content and Pressure of Repressing on the Porosity of Stiff Mud Brick," by Stuart M. Phelps.

Bulletin No. 12, June, 1927, "Experiences with Refractories in Furnace Construction," by Leo W. Briggs.

Bulletin No. 13, July, 1927, "Report on Activities of Committee C-8 on Refractories of the American Society for Testing Materials."

Preprint

"The Variation of Size Occurring in Clay and Silica Refractories," by Stuart M. Phelps and H. Foster Robertson.

Reprints

"The Action of Slag upon Silica, Magnesite, Chrome, Diaspor, and Fireclay Refractories," by R. M. Howe, S. M. Phelps, and R. F. Ferguson (1923).

"Adaptation of Tunnel and Car Kilns to Firing Refractories," by Philip Dressler (1925).

"American Industrial Progress through Scientific Research," by Edward R. Weidlein (1927).

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"Automatic Kiln Stokers," by John D. Martin (1923).

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* "Vital Factors in the Testing of Fireclay Refractories and in the Interpretation of Results," by Raymond M. Howe.

* "What Every Manufacturer Should Know about His Product," by Porter S. Kier.

"The Work of the Technical Division of the Refractories Manufacturers Association," by R. M. Howe (1919).

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* Our supply exhausted. For reference only.

CALENDAR OF CONVENTIONS

Amer. Assn. for the Advancement of Science	Dec. 28–31, 1927	Nashville, Tenn.
AMERICAN CERAMIC SOCIETY		
Annual Meeting	Feb. 5–11, 1928	Atlantic City, N. J.
Ceramists' Tour Abroad	May 19–July 5, 1928	See p. 313
American Concrete Institute	Feb. 28–Mar. 1, 1928	Philadelphia, Pa.
American Engineering Council	January, 1928	Washington, D. C.
Amer. Gas Association	Oct. 10, 1927	Chicago, Ill.
Amer. Inst. Mining and Met. Engrs.	February, 1928	New York City
Amer. Mining Congress	1st week Dec. 1927	Washington, D. C.
Amer. Soc. Mechanical Engrs.	Dec. 5–8, 1927	New York City
Fuels Division	Oct. 10–13, 1927	St. Louis, Mo.
Spring Meeting	May 14–17, 1928	Pittsburgh, Pa.
Hollow Building Tile Assn.	February, 1928	Chicago, Ill.
Natl. Assn. of Mfgrs.	Oct. 25–27, 1927	Chattanooga, Tenn.
Natl. Academy of Sciences	Oct. 18–20, 1927	Urbana, Ill.
Natl. Exposition of Power and Mech. Engineering	Dec. 5–10, 1927	New York City
Optical Society of America	Oct. 20–22, 1927	Schenectady, N. Y.

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1909-1910	Pittsburgh, Pa.	1924-1925	Columbus, Ohio
1910-1911	Trenton, N. J.	1925-1926	Atlanta, Ga.
1911-1912	Chicago, Ill.	1926-1927	Detroit, Mich.
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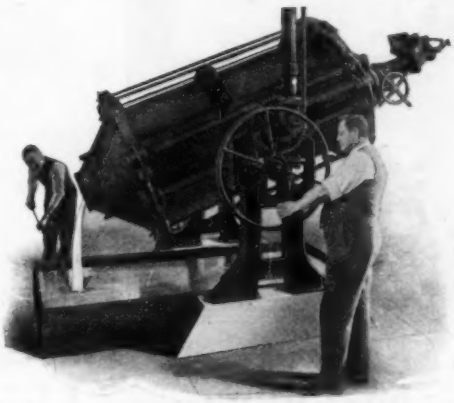

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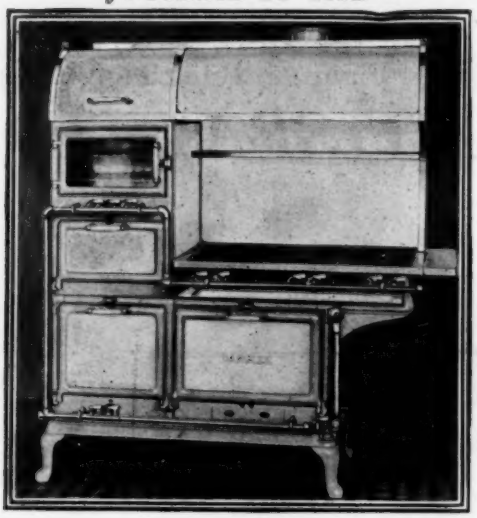

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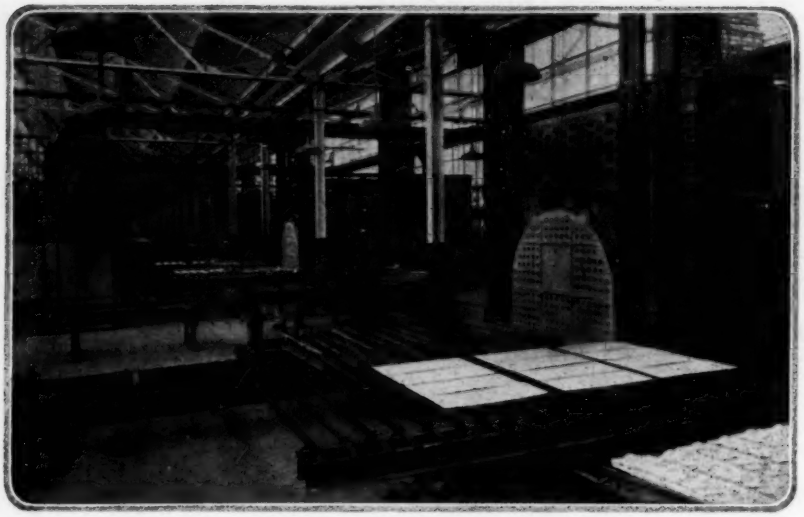

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CERAMIC BREVITIES

The Hauck Brothers Company of Centerville, Calif., announce the merger of their plant and organization with The Ferro Enameling Company of California. H. B. Naylor is manager of the latter plant.

Mr. Henry Connor has severed connections with the Chattanooga Stamping and Enameling Co., Chattanooga, Tenn., to become associated with The Ferro Enamel Supply Company of Cleveland, Ohio.

The Geo. D. Roper Corp. of Rockford, Ill., recently built a new porcelain enameling department. Four large sized porcelain enameling furnaces were installed by The Ferro Enamel Supply Co., Cleveland, Ohio.

A. F. Stein, formerly with The Ferro Enameling Co. of California, is now in the Enameling Dept. of the Regent Stove Company, Wyandotte, Mich.

A delegation of English China Clay producers arrived on this side last Friday aboard the SS. Berengaria. They are visiting the important interests here with reference to existing trade conditions and to ascertain more accurately the requirements of the China Clay consumers.

Owing to the rapid growth of demand for Brown Pyrometers, Gauges and Flow Meters in Kansas and surrounding states, The Brown Instrument Company, Philadelphia, Pa., has established a new branch office at Kansas City, Mo., territory covered by this office includes the states of Kansas, Nebraska, the western part of Missouri and the city of Council Bluffs, Iowa. Mr. F. M. Poole will be District Manager in charge. The address of the new office is 509 Mutual Building. Telephone Victor 7608.

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(See page 44 for additional items.)

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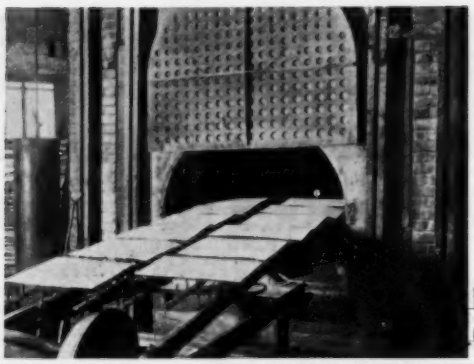

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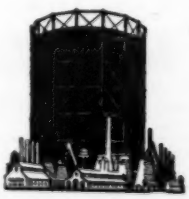

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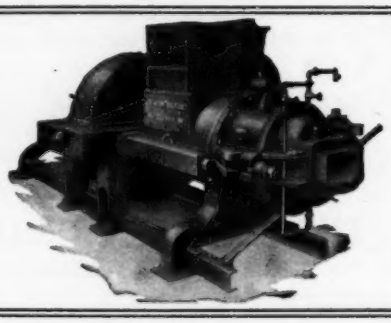

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BORAX *Guaranteed 99½%-100% Pure* **BORIC ACID**

Select the Brand which has back of it years of *successful use* by experienced Ceramists.

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Miners and distributors of high grade ball, sagger and plastic fire

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Established 1914

Electric Furnace Plants { **THOROLD, ONTARIO** / **STAMFORD, ONTARIO**

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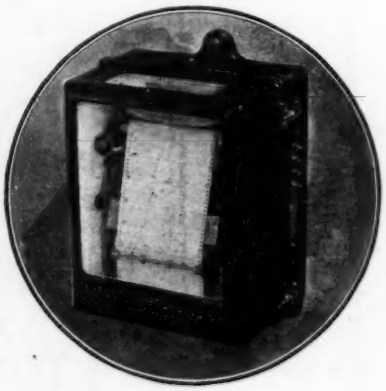
Here is the coal the "jack" bought

(Unburned carbon goes out the stack as smoke or deposits as soot; it's a total loss of B.t.u. Partly burned carbon goes out as CO, an invisible gas; it's a partial B.t.u. loss—from 50 to 30%, according to the Bureau of Standards.)

Here is the man who bought the coal to heat the kiln to burn the ware.

Here is the money he might have saved with temperature records from Engelhard Type S Recorder.

The Question is: Will you have our Ceramic Engineering Dept. show you the dollars - and - cents savings possible in time, labor, fuel and improved quality of ware? The service is made without charge.



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For saggers, refractory shapes, super-refractories, mullite bodies, etc.

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Producers and Grinders of *Sacandaga Rock Flint*

Especially adapted for the manufacture of ivory bodies.

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The Main Spring

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Elevating and Conveying Machinery

Your watch may be of 23 jewel quality, but if the main spring is not up to the same standard, the other parts are of little value.

Just when you want it most—to keep an important engagement or to catch a train—it will not be dependable.

Likewise, a weak chain on your elevator or conveyor usually selects a rush period to break and cause trouble. Your whole production system may be tied up and a gang of idle workmen placed on the payroll. Failing to make a shipping date that you have promised faithfully completes the picture of unreliable MAIN SPRINGS in your material handling system.

A good Jeffrey Chain costs no more than many inferior products and there's a Jeffrey Chain for every material handling service.

Catalog 415-I gives complete specifications for Jeffrey Chains used in every industry.

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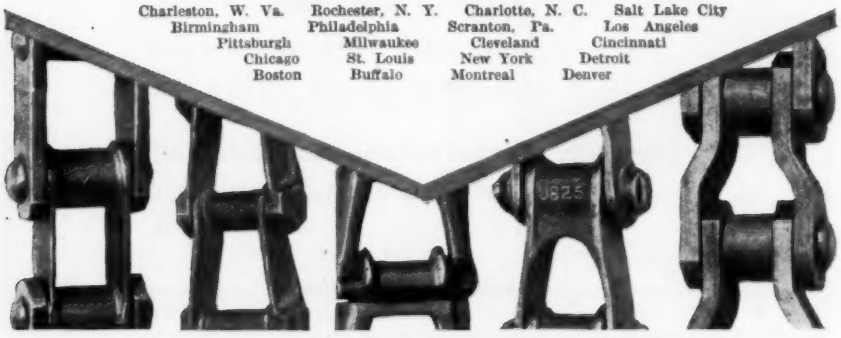

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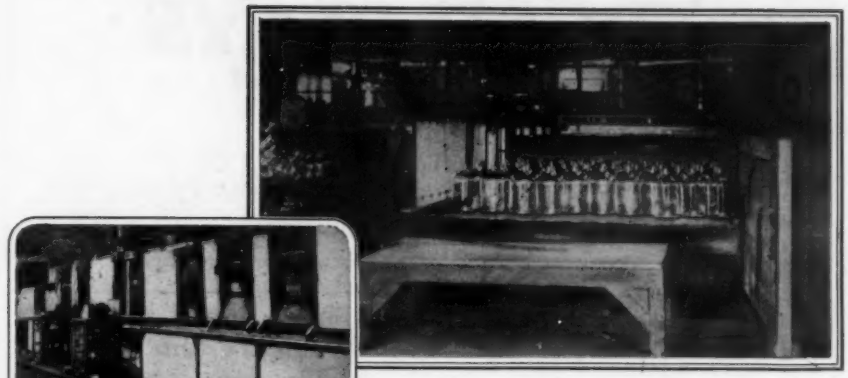

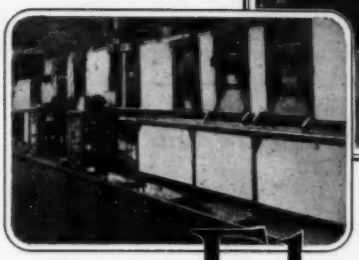

Electric Heat

cuts annealing time 50%

Although electric heat will not supplant all other forms of heat for industrial purposes, there are processes in every industry where it is the ideal heat—the most economical heat—the heat that ultimately will be used.

ULTIMATELY ELECTRIC HEAT IN EVERY INDUSTRY

Electric Heat continues its revolutionary work in glass annealing at the Alton, Ill. plant of the Ilinois Glass Company. And as usual the results are obtained in G-E equipped lehrs* In these lehrs, 5-gallon bottles are annealed 100%; the time of annealing has actually been cut in half; the annealing space, or lehr space, has been reduced 33%; and the quality of the bottles has been so improved that customers are outspoken in their appreciation.

The glass industry is coming to electric heat. There is great advantage, however, in coming to it first. Your nearest G-E office will supply you with information.

**Every electric lehr in the country is G-E equipped.*

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Are Always as Represented

Testing Samples Gladly Sent

EDGAR PLASTIC KAOLIN CO.

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METUCHEN, N. J.

Virginian High Potash Spar is the only

North American Feldspar

used in the manufacture of ***French Porcelain***

It is also used by many of the most discriminating American manufacturers.

THE SEABOARD FELDSPAR COMPANY

430 Hearst Tower Bld., Baltimore, Md.

Patent applied for

LaMOTTE ROULETTE COMPARATOR

The ideal equipment for hydrogen ion control in all branches of the Ceramic Industry. Practical, simple and accurate.

Write for a copy of "The A B C of Hydrogen Ion Control" which explains this valuable control method in simple language. Free on request.

LaMotte Chemical Products Co.
414 Light St., Baltimore, Md.

CERAMIC BREVITIES (Continued)

Announcement is made of the purchase of the controlling interest in The American Resistor Corporation of Milwaukee, Philadelphia and New York by The Carborundum Company of Niagara Falls, N. Y. The principal products of The American Resistor Company are non-metallic electrical heating elements and resistors which are marketed under the trade name of "Globar." The new company will be known as Globar Corporation and has been incorporated under the laws of the State of New York.

"Globar" is a Carborundum product being produced in the form of rods or bars of Carborundum, the inherent characteristics of which lend it admirably to the conducting of electrical current and when the current is passed through the bar it is possible to obtain a glowing heat up to 2600 degrees Fahr. The Globar element has a wide application both in the industrial and in the domestic fields. For instance it has met with great success in providing a quick, closely controlled, clean heat in heat treating and tempering furnaces, forging furnaces, annealing furnaces, etc., and has met with outstanding success in automobile and other industrial plants. Globar is also used in heating of glass lehrs, ceramic kilns, enameling furnaces, driers, etc.

Plans are now underway for the exhibit to be held in connection with the 30th annual meeting at Atlantic City, N.J., February 5-11 inclusive.

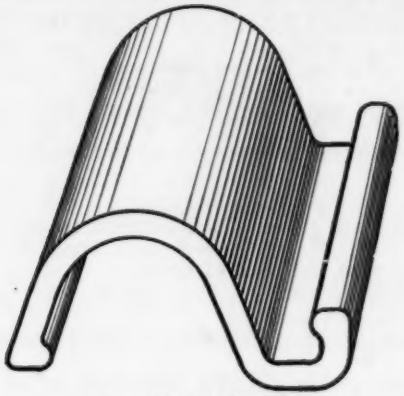
If you have not given consideration to your exhibit, it will pay you to do so at once.

The arrangements this year are the best in the history of the Society. All members attending the meetings will have to pass and repass the exhibit spaces in order to get to the various meeting rooms. No exhibit, regardless of the space occupied, can be overlooked.

Complete details will be ready for distribution about December 1st. In the meantime you should plan on the best ceramic exhibit you ever made.

AMERICAN CERAMIC SOCIETY

Reduce Losses
USE "HURRICANE" DRYERS



Spanish Roofing Tile

A Midwestern manufacturer of Spanish Roofing Tile formerly lost from 18 to 24% of his tiles in drying.

A "HURRICANE" Tunnel Truck Dryer, with proper temperature regulation and operating on a regular time schedule, reduced this loss to *practically nil*, and the time of drying was *reduced* from 72 to 84 hours, to 42 hours.

Under the old system, drying results were extremely irregular, most days showed a very high percentage of spoilage. *UNIFORM* results are now obtained with the "HURRICANE" Dryers.

The success of this installation has induced the manufacturer to install "HURRICANE" Dryers in other plants.

The Philadelphia Drying Machinery Co.

Stokley Street above Westmoreland, Philadelphia, Pa.

New England Office: 53 State St., Boston, Mass.

HURRICANE
Ideal Drying Every Day

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